THE OPERATIVE TREATMENT OF CHRONIC INTESTINAL STASIS

W. ARBUTHNOT LANE
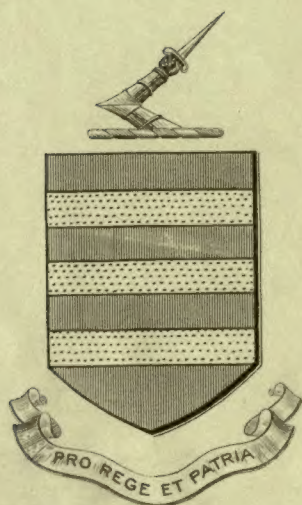
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THE

OPERATIVE TREATMENT

OF

CHRONIC INTESTINAL STASIS

BY

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PREFACE.

IN the two preceding editions I employed the title "Chronic Constipation" instead of the more comprehensive and scientific term "Chronic Intestinal Stasis." I did so for the reason that the delay in the large bowel is the primary or causal factor of the condition, and because the title Chronic Constipation at that time called for less explanation than that which I have now rendered familiar to the profession. The chapters by Dr. Jordan, Dr. Nathan Mutch, and Dr. James Mackenzie will serve to make the subject clearer from the radiological, bacteriological, chemical, and clinical aspects.

W. ARBUTHNOT LANE.

21, CAVENDISH SQUARE
1915.

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CHAPTER I

In order to consider the subject of chronic intestinal stasis in any detailed manner, it will be best to deal with it from its very beginning, and I shall commence by reminding you of several most important general laws which I formulated many years ago with regard to the skeleton and its articulations. I shall then proceed to demonstrate that precisely the same laws govern the soft parts and modify their structures, and that a knowledge of the several mechanical conditions which bring about chronic intestinal stasis is largely dependent on a recognition of these fundamental principles.

The skeleton represents the crystallisation of lines of force which when exerted in a single direction are laid down as compact tissue; when in varying directions as cancellous. In young life any alteration in the length of a long bone following on a fracture in which the fragments have not been replaced in accurate apposition results in the formation of a new shaft and the absorption of the old one to an extent which varies with the alteration in the form of the bone. This process takes place in a degree inversely proportionate to the age of the child. The same important fact holds good also of changes which develop in the abdomen. Later in life a lesser, but similar, change may be brought about by the artificial engorgement of the part

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with blood, and much of the deformity and shortening
which would otherwise occur can thus be obviated.

It follows as a complement to this latter law that "the
rates of bone formation in the several portions of a growing
line vary inversely as the pressure transmitted through
them," and, incidentally, it is by the exercise of these
mechanical principles that Nature reduces to a minimum
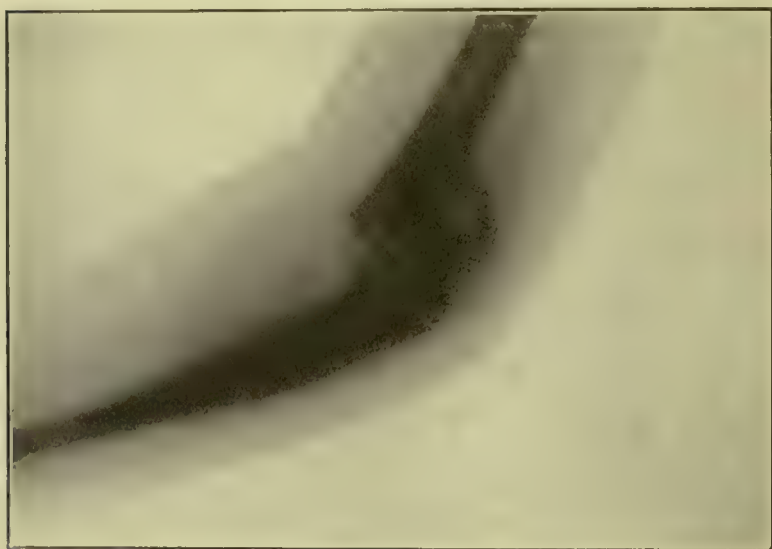
Fig. 1.

the harm done by the incapacity of the surgeon in the
treatment of fractures in young life. The accompanying
skiagrams illustrate the action of these laws:

Fig. 1 represents a fracture about the lower epiphysis
of the humerus with backward displacement of the frag-
ment. Six weeks had elapsed since the injury. A dark
zone extending vertically upwards from the epiphysis
behind the shaft indicates the commencement of the
crystallization of the lines of force.

Fig. 2 represents the condition three months after the injury. The perceptible layer of callus extends a greater

Fig. 2.

distance up the back of the shaft. The shadow formed by it is much darker, equalling that produced by the original shaft.

Fig. 3 shows the part six months after the injury.   The
range of flexion has increased partly by the absorption of
the end of the shaft and partly by that of the coronoid
process.   The layer of new material, which is extending

Fig. 3.

much farther up the shaft, is denser, while the shaft is
relatively lighter.

Fig. 4, taken sixteen months after the fracture, shows
that flexion is still further increased by progressive absorp-
tion, while the changes already noted in the original shaft
and in the new formation are much more marked.

Fig. 5, taken three years after the injury, shows that a new shaft connecting the extremities of the bones has been laid down, while the original one has almost completely disappeared. The range of flexion is still further increased.

FIG. 4.

On general principles we see that the necessity or the importance of effecting a complete restoration of the form of the fractured bone varies directly with the age of the individual.

Again, by altering the mechanical relationship of the individual to his surroundings, a skeleton is produced

Fig. 5.

which differs from the normal often to an extent greater than the normal does from that of the higher ape. A study of the development of such changes in the skeleton which clearly occur during the lifetime of the individual shows them to be governed by the three following laws:

(1) That pressure produces changes in the structure and form of the bones and in the form and function of existing joints, while it determines the formation of new joints.

(2) That strain produces change in the form of the bones, and in the form and function of existing joints, and also produces new joints.

(3) That when, apart from the exercise of pressure or strain, it is important, from the altered mechanical relationship of the individual to his surroundings, that a mechanism should be modified or an entirely new one developed, such a change takes place.

The normal form of the skeleton and of the soft parts depends on a normal combination of attitudes of activity with attitudes of rest. If attitudes of rest are habitually assumed these attitudes become fixed and then exaggerated. If, on the other hand, certain attitudes of activity are habitually affected these also become fixed and later exaggerated. In other words, while an attitude of rest or of activity is being assumed on a single occasion there exist certain tendencies to change. If these attitudes are assumed habitually then these changes become progressive actualities, the result of which is to produce such very definite alterations in the form of the skeleton that the life-history of the individual can be readily determined not only from the examination of the whole skeleton, but frequently from that of a single bone.*

* " The Causation, Pathology and Physiology of several of the Deformities which develop during Young Life,"·'Guy's Hosp. Reports,' (1886) 1887, xliv, pp. 241–333; and " The Causation and Pathology of the so-called Disease, Rheumatoid Arthritis, and of Senile Changes," 'Trans. Path. Soc.,' Lond., 1886, xxxvii, pp. 387–447.

The space at my disposal renders it impossible for me to consider at any length the work on this subject which I did many years ago in the dissecting room, and which has served as a perfectly secure groundwork on which has been based what little surgical work I have since been able to do. I would, however, remind you of the anatomy of certain labourers which afford excellent instances of the fixation and exaggeration of the tendencies to change which exist when a certain attitude is assumed habitually, and also of the fact that the same holds true of resting postures as illustrated by flat-foot, knock-knee, dorsal excurvation, lateral curvature, etc. I have much hesitation in inflicting these details upon you, but I am driven to do it as there exists still the same tendency on the part of many surgeons to consider any deviation from the normal as being congenital or inflammatory in origin. Just as pathologists used to regard all the evolutionary bone and joint changes of the labourer as being the result of a disease called osteo- or rheumatoid arthritis, so they now consider the acquired bands and mesenteries about the intestines as being congenital or inflammatory in origin, and employ such terms as pericolitis, mesosigmoiditis, etc., to indicate their causation. I fear it would be useless for me to attempt to alter the creeds of those who have possessed them for a long time, but I hope to induce the younger members of our profession to interest themselves in the mode of development of these evolutionary processes in the skeleton before arriving at a definite conclusion on the subject.

To show the changes that arise in the skeleton which are obviously evolutionary in the lifetime of the individual by the habitual assumption of an attitude or sequence of attitudes of activity, I am employing the following illustrations which have all been fully described in early papers. Here I must necessarily describe them very briefly. I do
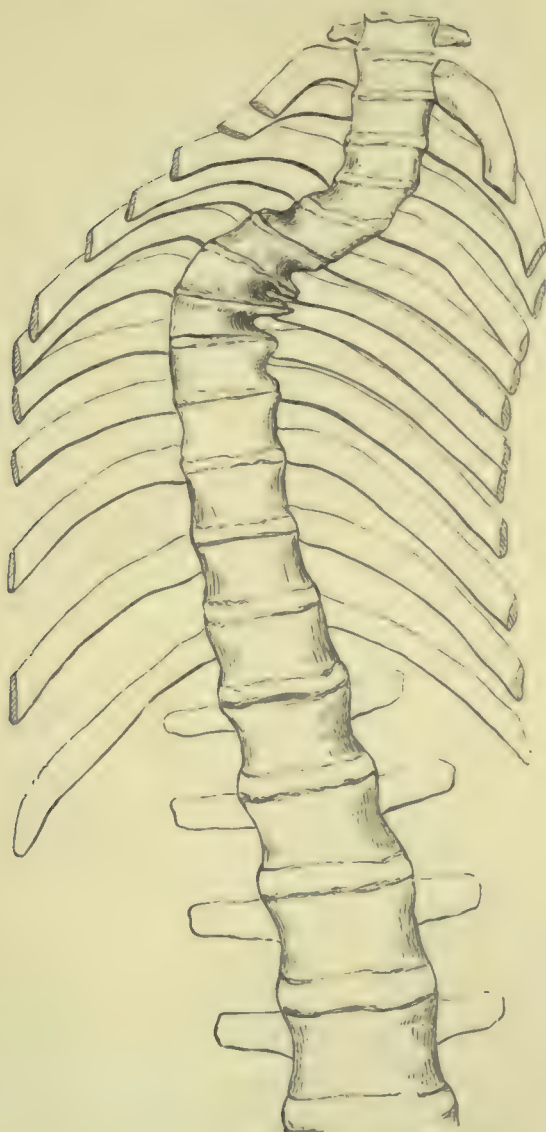
Fig. 6.—Spine and ribs of a brewer's drayman.

so with the distinct object of illustrating the three laws I
have already referred to.

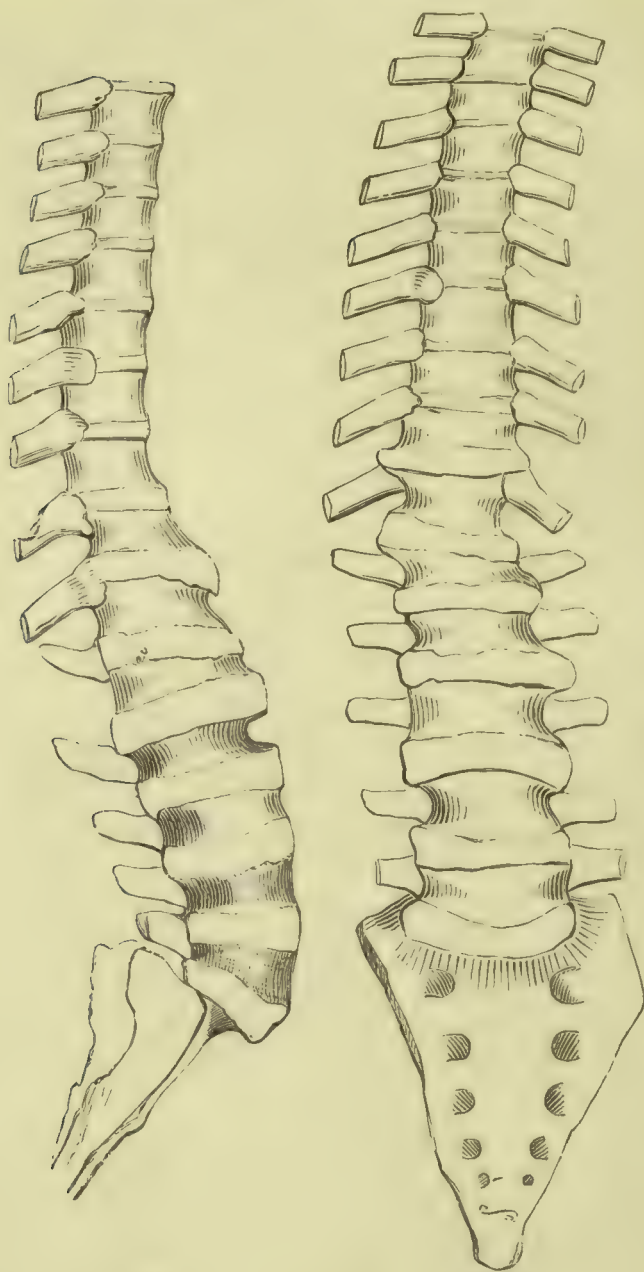Fig. 6 represents portions of the spine and thorax of a

Fig. 7. Fig. 8.

Fig. 7 shows a lateral view of a coal-heaver's spine, and Fig. 8 an antero-posterior one.

brewer's drayman, and shows the fixation and exaggeration of the attitude of activity which is assumed when a heavy barrel is supported on the right shoulder. The alteration in form is occasioned by a change in the shape of the ribs, by the destruction of the fibro-cartilages and the bone at the seat of greatest pressure, and by the formation of thick osseous lips at the margins of the articular surfaces to increase the security and strength of the spine. In this manner an almost rigid shelf is formed on which the barrel can be supported and through which the weight can be transmitted with a minimum expenditure of muscular energy.

Figs. 7 and 8 represent the spine of a coal-heaver. They show much destruction of fibro-cartilages, and the fixation of the margins of the vertebræ one to another by dense lips of bone which practically render the lumbar spine immobile. In Fig. 9 the last lumbar vertebra is displaced forwards, and is ankylosed to the sacrum, forming a variety of spondylolisthesis. Contrast the conditions present here with those in Fig. 10, where an arthrodial joint has been developed. This specimen was obtained from the body of a labourer whose business it was to carry loads, lifting them from the ground and replacing them.

In contrast with Figs. 9 and 10, Fig. 11 shows the condition of the lower part of the spinal column in a labourer who was habitually engaged in carrying loads in front of him. The constant over-extension of the spine resulted in a backward displacement of the fifth lumbar vertebra on the sacrum, and an exaggerated development of the spines of the lumbar vertebræ and sacrum, which articulated with one another, transmitting a considerable proportion of the superjacent weight. This subject is dealt with in a paper published in the 'Transactions of the Obstetrical Society,' 1887, xxiv, "The Mechanical Factors which determine the Form of the Pelvis in the two Sexes." The destruc-

tion of fibro-cartilage occurs as in all other laborious occupations.

Fig. 9.—Fourth and fifth lumbar vertebræ and sacrum of coal-heaver.
Fig. 10.—Fifth lumbar vertebra and sacrum of deal-porter.

Fig. 11.—Fourth and fifth lumbar vertebræ and sacrum of labourer who carried loads in front of him.

Figs. 12 and 13 show the changes which result from habitually carrying heavy loads on the head. Fig. 13 is a vertical antero-posterior section of the same specimen. The

lateral curves should be noted, serving presumably to render the column less rigid. The destruction of fibro-cartilage,
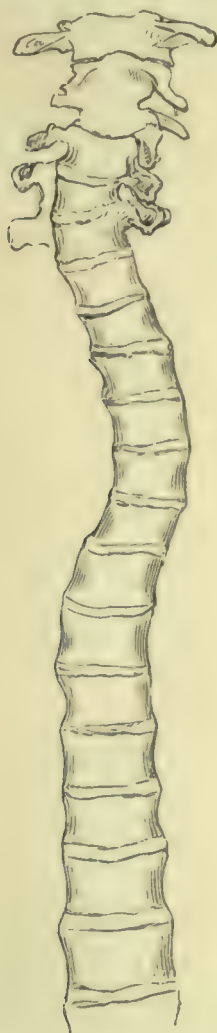
Fig. 13.

Fig. 12.
Spine of labourer who carried loads on his head.
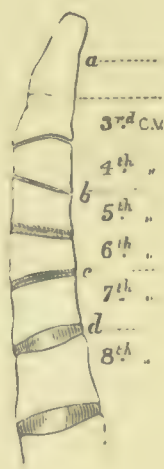
the formation of arthrodial joints in the upper part of the cervical spine, and the ankylosis of the second and third cervical vertebræ, are also indicated. ·

Fig. 14 is a vertical median section through the lower part of the spinal column of a coal-trimmer.* It shows the formation of an arthrodial joint in the fibro-cartilage between the fourth and fifth lumbar vertebræ, and the

Fig. 15.

Fig. 14.
Fig. 14.—Lumbar vertebræ and sacrum of coal-trimmer.
Fig. 15.—Seventh cervical and first dorsal vertebræ of coal-trimmer.
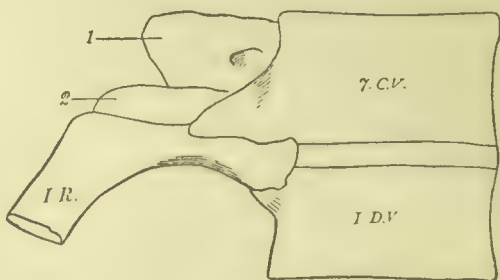
fourth arch divided at two points. This division is seen more clearly in Fig. 16, and has resulted from the forcible rotation of the spine on a vertical axis which takes place

* " A Remarkable Example of the manner in which Pressure Changes in the Skeleton may reveal the Labour History of the Individual," ' Journ. of Anat. and Physiol.,' 1886–87, xxi, pp. 385–406.

when coal is thrown with great force to a considerable distance behind this labourer when engaged at his work. Fig. 15 represents the seventh cervical and first dorsal vertebræ with the first rib, and the arrangement by means of which the head of the first rib is secured so as to obtain a firm and powerful hinge-joint.

Figs. 17 and 18 illustrate the changes which develop in the right femur of the coal-trimmer in consequence of the special functions it performs ; the area of impact of the

Fig. 16.—Fourth lumbar vertebra of coal-trimmer.

neck of the femur locking and limiting the range of movement of the joint being shown very clearly.

Fig. 19 shows the conversion of the first costal cartilage directly into bone under the influence of strain with the development of a new joint in the ossified cartilage ; also the formation of a new joint between the clavicle and first costal arch, and of a similar anthrodial joint between the coracoid process and clavicle. All these evolutionary changes take place in the fully developed skeleton.

In Fig. 20 the joint, probably anthrodial originally, has become amphi-arthrodial with very limited movement, while in Fig. 21 the joint has been obliterated.

The second general law—namely, the influence of strain on the skeleton—is very well illustrated by Figs. 22 and 23. They represent, respectively, the scapula of a shoe-maker and a deal-porter, the latter having carried his load
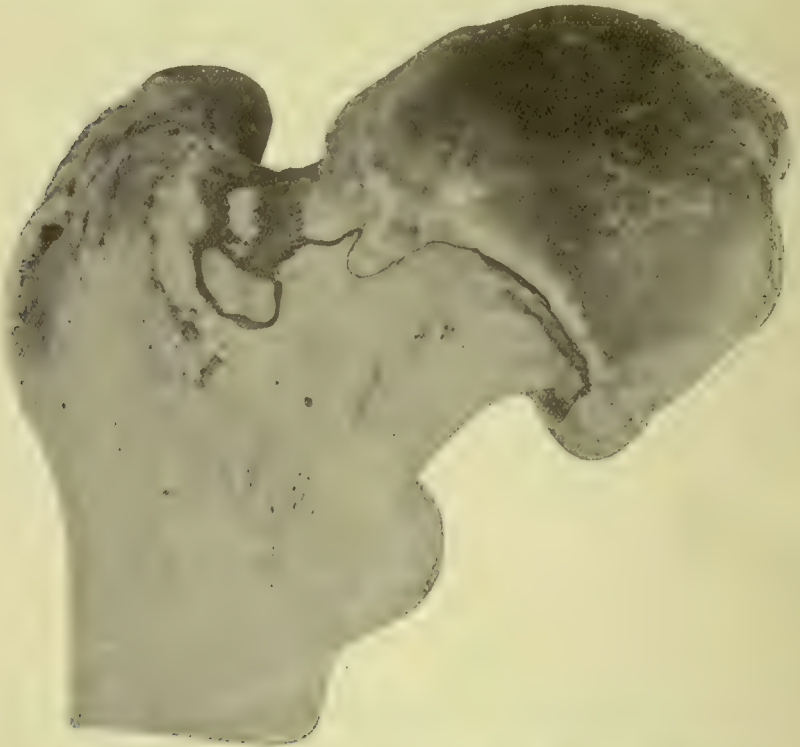
Fig. 17.—Anterior aspect of upper extremity of right femur of coal-trimmer.

habitually on the right shoulder. Besides the pressure changes as shown by the character of the acromio-clavicular and shoulder-joints, Fig. 22 shows the result of strain exerted chiefly on the trapezius and levator anguli scapulæ, and Fig. 23 the very great breadth of the acromion process which develops in consequence of the strain on the back of the deltoid, and the eversion of the margins of the supra-spinous fossa from that sustained by the supra-spinatus

muscle. The strain on the infra-spinatus and teres major muscles, and upon the rhomboids during the process of pulling the threads by the shoemaker, has left a very definite impress on the bone.*

Fig. 18.—Posterior view of upper extremity of right femur of coal-trimmer.

The third law, viz., " that a pre-existing mechanism may be modified or an entirely new one formed apart from the influence of pressure or strain," is well illustrated by a new joint which develops in the shoemaker. This structure is not present in the normal skeleton. During the jerk upon his thread, the head, which is held somewhat obliquely as regards an antero-posterior axis upon the spine, is rendered

* "The Result produced upon the Muscles, Bones, and Ligaments by the Habitual Exercise of Excessive Strain," ' Brit. Med. Journ.,' 1888. ii, p. 1205.

more secure by the formation of a buttress of bone, which extends upwards from the lateral mass of the atlas on the one side and articulates, by means of an arthrodial joint, with the jugular process of the occipital bone. This is shown in Fig. 24, which represents the under surface of the occipital bone, c being the acquired facet.
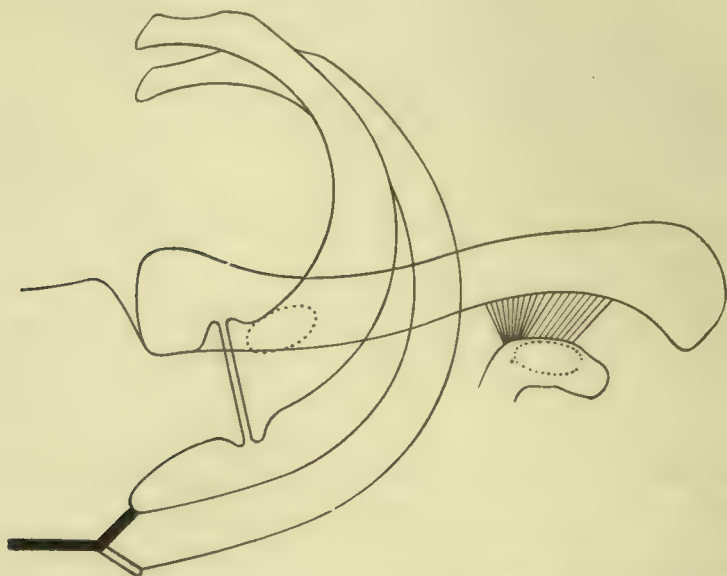
Fig. 19.—Represents the left first and second costal arches, with the manubrium, clavicle, and coracoid process of a labourer.

Fig. 25 represents the anterior surface of the atlas with a prolongation upwards from its anterior arch, also the large quadrilateral column of bone which stands upon the upper surface of the left lateral mass and articulates with the jugular process of the occipital bone.

Fig. 26 represents the axis and third cervical vertebra of the shoemaker, the prolongation upwards of the odontoid process, with its articular facet, the formation of a layer of bone connecting the arches of the axis and third cervical vertebra, and the position of the ankylosed articu-
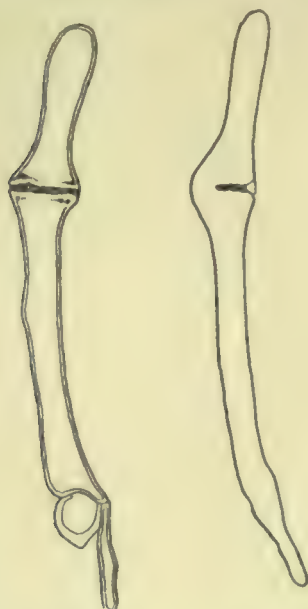
FIG. 20.   FIG. 21.

Figs. 20 and 21 show the changes that take place in the manubrio-gladiolar joint in consequence of the transmission through it of great pressure. These specimens were obtained from the bodies of labourers who had been engaged in heavy porterage work at the docks.

FIG. 22.—Scapula of shoemaker.   FIG. 23.—Scapula of deal-porter.

lation of the articular process.   The cause of the destruc-
tion of the intervening soft parts, and the union of the
vertebræ to one another in this as in other laborious
pursuits, is fully explained in the original paper in the
' Journal of Anatomy and Physiology,' July, 1888, " The
Anatomy and Physiology of the Shoemaker."*   I have
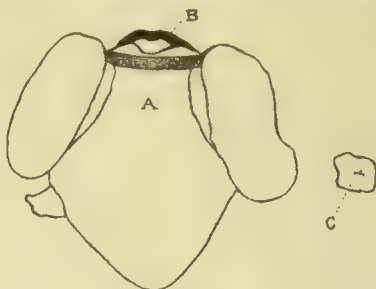
FIG. 24.

FIG. 25.—Atlas of shoemaker.

FIG. 26.—Axis and third cervical
vertebra of shoemaker.

frequently seen these conditions exhibited as cured tuber-
cular or other disease of the spine by surgeons, and
congenital union of bone by anatomists.   Besides showing
very clearly the great changes which result from the
habitual exercise of very considerable pressure, the elbow-
joint of a coal-trimmer illustrates the same law, since both
the olecranon and coronoid depressions have been filled up
by dense bone-joint sufficiently to limit the range movement
in the elbow to the extent requisite for the perfect

* ' Journ. Anat. and Physiol.,' 1888, xxii, pp. 593–628.

performance of the occupation of a coal-trimmer.   Such a
change cannot result from pressure or from strain, since

Fig. 27.—Right elbow-joint of coal-trimmer.

these cavities are not exposed to the action of force in this
manner, but it arises because it is advantageous and
economical to the individual in his peculiar relationship to
his surroundings, or, in other words, in his occupation.

In Fig. 27 the joint is shown at its limit of flexion. The manner in which the humero-ulnar segment is strengthened by buttresses of bone, which increase the area of the articular surfaces and render the fit more accurate, is noteworthy.   The range of flexion and exten-

FIG. 28.—Lower end of right humerus   FIG. 29.—Upper end of right radius of
of coal-trimmer.   coal-trimmer.
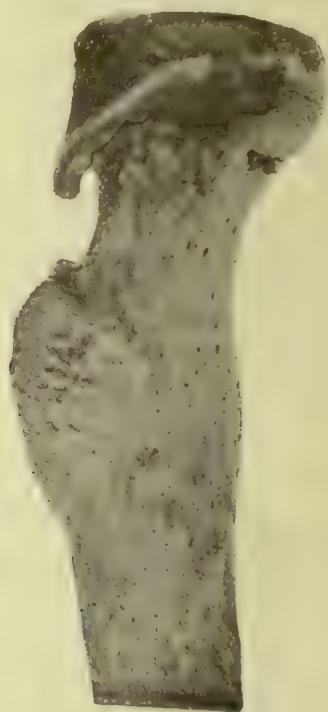
sion is much limited, for reasons of economy, by the formation of bone in the coronoid and olecranon fossæ. These are seen in Fig. 28, where the coronoid fossa and the depression for the head of the radius are rendered shallow by the deposit of bone on their floor.

Again, an attitude of rest, if assumed habitually in the child, becomes fixed and exaggerated.   Here the presence of the growing line assists in the production of an alteration

in the form of the bones, this factor being usually absent in the labourer, who does not commence to do heavy work

Fig. 31.—Lower part of spine of feeble old subject.

Fig. 30.—Spinal column of old woman.

till his skeleton is fully developed. The attitude of rest in advanced age can best be studied in the skeleton of the feeble old subject.

Many of the changes in feeble old age are illustrated in the following diagrams :

Figs. 30 and 31 represent vertical median sections through the bodies of feeble old subjects. Note the resting position of complete flexion of the several parts of the spine. In the lower part of the spinal column the habitual flexion of the lumbo-sacral joint has resulted in an abrupt bend of the sacrum in the one case and in the other of a more general yielding, producing in both a considerable diminution of the conjugate diameter of the pelvic brim. The intervertebral discs disappear at the points of greatest pressure, their total bulk being proportionately very much less than in vigorous life. The shading represents alteration in the structure of the bones, loss of function of a part rendering the cancelli less conspicuous, while the transmission of an excessive pressure exaggerates them.

So far I have confined my remarks and illustrations entirely to the consideration of the bony skeleton and its articulations ; what I wish now to do is to point out that the same mechanical principles govern the soft parts and modify their structure, at the same time bearing in mind that the several viscera, and much more especially the brain, exert a varying influence on the bone-forming capacity of the individual.* All these evolutionary pro-cesses are useful to the individual in his special mechanical relationship to his surroundings, since they economise expenditure of energy. One must, however, recognise that while these processes are advantageous in the pursuit of his particular occupation, they are subsequently all more or less instrumental in tending to shorten his life.

We are quite familiar with the relatively short life of the labourer, the duration of whose existence may be said to vary inversely as the severity of his occupation as regards manual work. How far these mechanical agencies act as

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* "The Factors which determine the Hypertrophy of the Skull in Mollities Ossium, Osteitis Deformans, Rickets, and Hereditary Syphilis," ' Lancet,' 1888, i, p. 815.

evolutionary factors in determining changes in the offspring I have considered in an earlier paper.*

In civilisation the trunk is retained in a vertical position during the entire daytime, the reclining posture being only assumed at night. Even then the horizontal posture is modified in character from that normally assumed in savage life. The resting posture of the trunk is the prone posi-
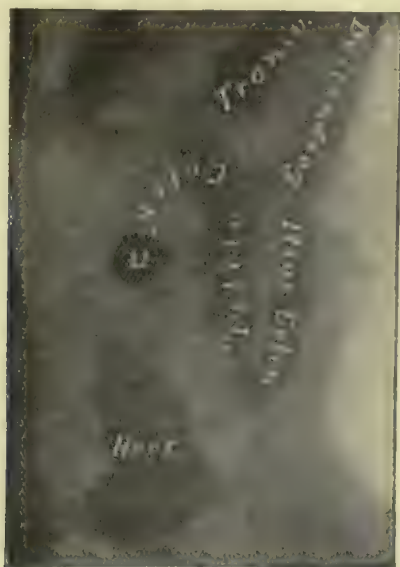
FIG. 32.

tion, which is that which is naturally assumed in sleep upon the ground. While in the erect position of the trunk all the viscera tend to displace downwards towards or into the true pelvis, in the prone position the tendency is for them to fall upwards and forwards out of or in a direction away from it. If these attitudes were assumed in a normal association the structures in the abdomen would retain their normal relationship to the abdominal wall and to one another. If, however, the attitude of activity is not com-

* "Can the Existence of a Tendency to Change in the Form of the Skeleton of the Parent result in the Actuality of that Change in the Offspring?" 'Journ. Anat. and Physiol.,' 1888, xxii, pp. 215-24.

pensated for sufficiently by the corresponding resting
posture changes will certainly take place, varying in degree
with the failure of compensation. It is now our business
to study in detail the changes which arise in the several
abdominal structures in consequence of this. The portion
which is affected in the first instance is our drainage
scheme, or, as it is commonly described, the gastro-intes-
tinal tract.

The large intestine forms the cesspool of this tract. As
it retains its contents for a comparatively long time, and as
most of these contents are of solid consistence, it is natural
that by its weight and situation it should tend to become
displaced earlier in the lifetime of the individual.

I believe the primary factor is a delay in the passage of
the contents of the large intestine. This is first obvious
in its termination, where, to prevent a tendency to elonga-
tion of the pelvic colon, the return of fæcal matter into the
descending colon, and also to obviate the prolapse of the
iliac colon into the true pelvis, lines of resistance are laid
down. These appear early in life as streaks on the outer
surface of the mesentery of the iliac and pelvic colon, and
particularly at the junction of the iliac with the pelvic
colon. These streaks appear first about the base of the
mesentery and gradually extend along its surface. After
a time they become thicker and more distinct, forming a
definite band which later separates more or less completely
from the peritoneal outer surface of the mesentery except
at its limits of attachment. The anchoring of this portion
of the bowel by this particular collection of acquired or
evolutionary adhesions I have called the first and last kink,
since it is the first to develop and the lowest in position in
the drainage scheme (see Figs. 32, 34, and 37).

Fig. 32 shows how this elongation of the pelvic colon
may take place in spite of every effort on the part of nature
to obviate its formation.
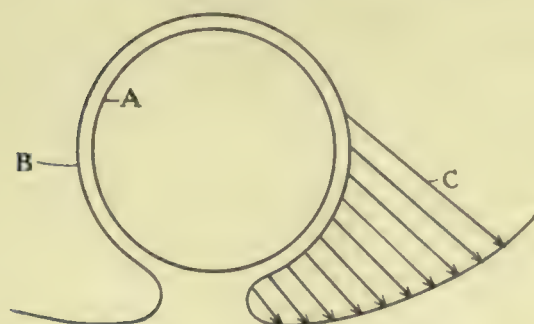
Fig. 33.
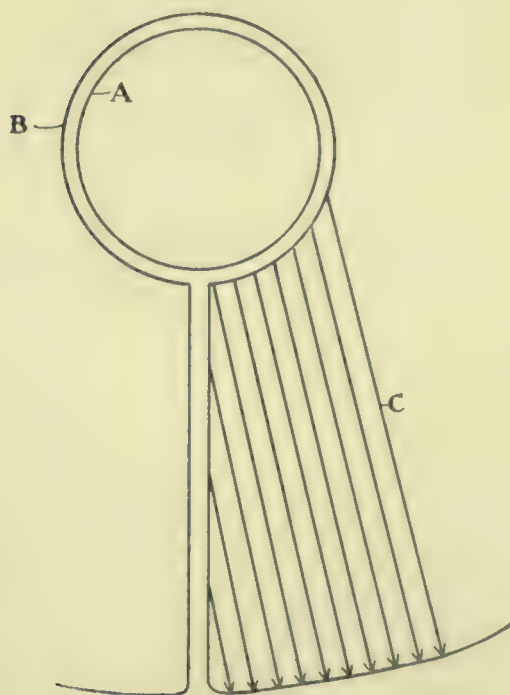
Fig. 34.

Fig. 33 represents diagrammatically the manner in which these acquired adhesions develop in the descending

colon where there is no mesentery.   B is the peritoneum,
A the bowel, and C the acquired adhesions which progress
from the reflection of the peritoneum outwards.

Fig. 34 shows the changes that take place in the
mesentery of the pelvic and iliac colon.

The left ovary and Fallopian tube are frequently
included in the grip of this acquired ligament. At first
they are merely secured to it, but later the ovary may be

FIG. 35.—Taken twenty hours after a bismuth meal in a man, æt. 54 years,
showing the short, straight sigmoid tied down, and its lumen narrowed
by adhesions, and numerous diverticula communicating with the central
lumen (confirmed by operation, and the patient cured). *U.*, umbilicus.

completely surrounded by it, and become embedded in its
substance. After a time, the ovary becoming enlarged
and cystic, re-acquires a peritoneal covering, and moves
freely in the newly developed space which it occupies in
the mesentery. After a time, as it enlarges still further,
an opening forms in the newly acquired peritoneal wall,
through which the ovary escapes, when it grows much more
rapidly in size. I have watched every stage of this con-
dition many times. A similar acquired ligament is formed
on the outer aspect of the mesentery of the descending and
iliac colon, becoming a more marked feature in the splenic

flexure. This flexure is made more acute by the drag upon it by these acquired adhesions as they contract and pull it upwards. The grip exerted by the acquired mesentery may be so firm as to fix the descending and iliac colon sufficiently to interfere with the free passage of material through this portion of the bowel, so that the intestinal wall is liable to yield in points, forming diverticula, which may later become inflamed owing to their being distended with fæcal matter, and infective changes may arise in the
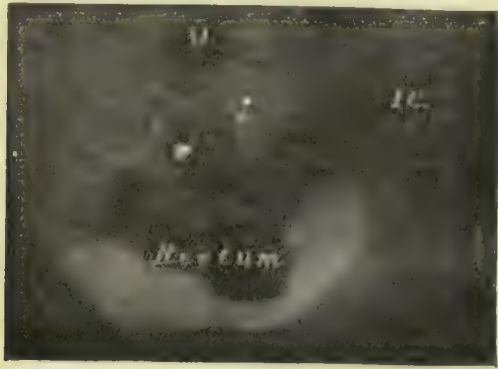
FIG. 36.

surrounding tissues. To this condition Dr. W. J. Mayo gave the very appropriate and simple name of diverticulitis.

This condition of diverticulitis is shown very clearly in Fig. 35, taken twenty hours after a bismuth meal in a man, æt. 54 years, showing the short, straight iliac and pelvic colon; the lumen of the pelvic colon narrowed, and numerous diverticula communicating with the central lumen. The condition of the parts as described was confirmed at the operation. The end of the ileum was implanted into the upper part of the rectum, and the patient made a perfect recovery, and gained greatly in health.

Fig. 36 shows the same portion of intestine three and a

half years after a short circuit.   A bismuth meal was found
to be all in the rectum after six hours, while some bismuth
had run up through the pelvic colon into the iliac colon,
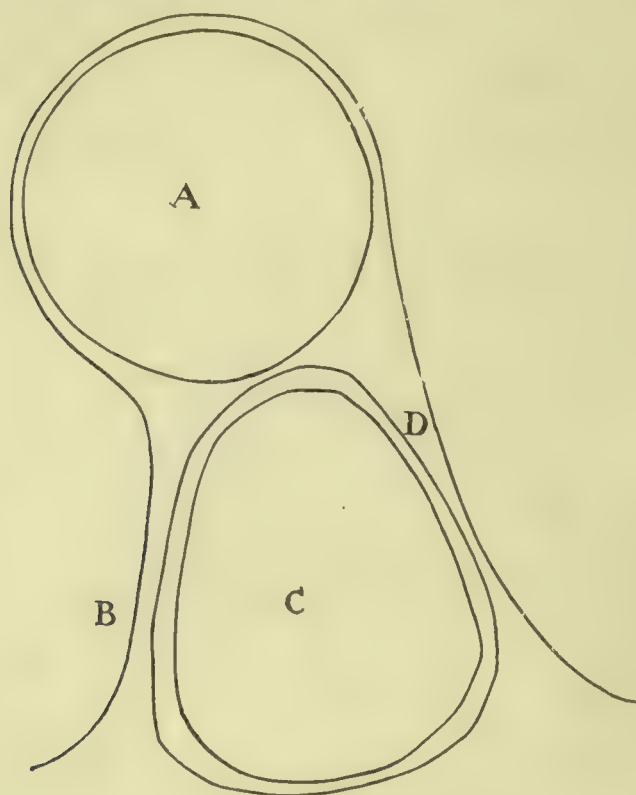
Fig. 37.

showing that the obstruction in this region had practically
ceased to exist.

Fig. 37 shows the left ovary included in the substance of
the adhesions which form the last kink. D is the portion of
membrane which covers in the ovary, which has increased
in size, having undergone systic degeneration.   The ovary
has become covered by a peritoneal covering, and lies in a
cavity lined by peritoneum.

If, on the other hand, the grip of the adhesions on the mesentery of the iliac colon especially is irregular, a large

FIG. 38.

dilated loop or two loops may develop in consequence of obstruction of their effluent, forming a condition which, when still further obstructed, is called a volvulus.

These conditions are represented diagrammatically in Figs. 38 and 39.

The same evolutionary developments continue on the
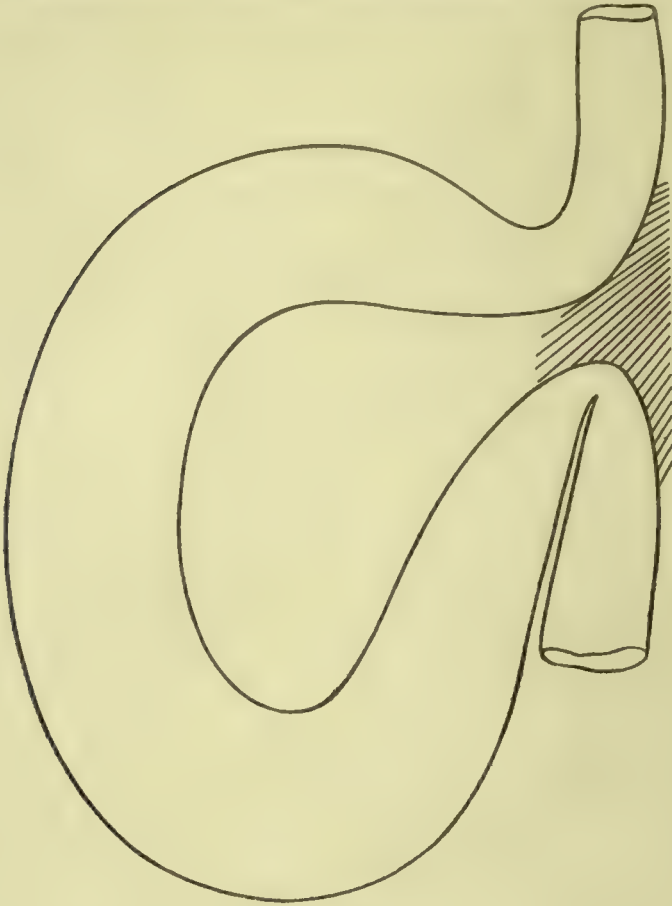
Fig. 39.

outer surface of the cæcum, ascending colon, and hepatic flexure with the same result.   Besides interfering with the free passage of material through the hepatic flexure, these bands may interfere with the lumen of any portion of the ascending or desending colon.

The layers which lie external to the cæcum may develop

into a mesentery of considerable strength, which covers the cæcum and sustains much of its weight in the erect posture.
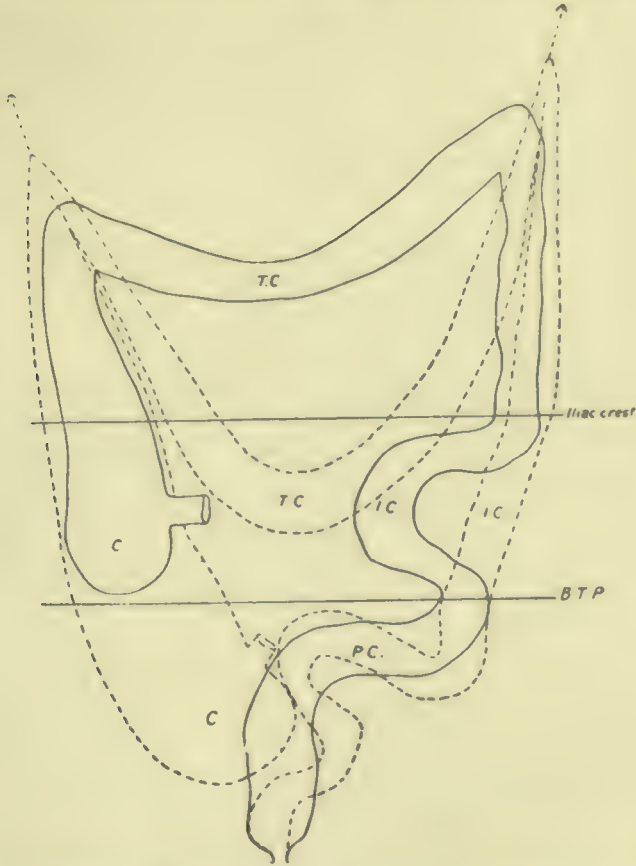
Fig. 40 represents the several variations from the normal which the large bowel undergoes. The normal condition is shown as a firm outline, and the altered condition as a dotted outline. Note the prolapse of the cæcum and transverse colon, the telescoping of the iliac colon, and the elongation of the pelvic colon. *B.T.P.* indicates the brim of the true pelvis. The hepatic and splenic flexures are drawn up and kinked by the development of acquired resistances shown as arrows.

These acquired resistances do not exist at birth, and their development can be observed during the several decades of life. Continuing these bands which lie external

to the cæcum are others which extend over the peritoneum
from the under surface of the cæcum and take their share in
supporting it.

The appendix not infrequently gets fixed in these
acquired adhesions along the outer or inferior surfaces of
the cæcum, and is made to take a share in supporting the
weight of this organ. It may be secured by its extremity
or at any point on its length. In the former case the drag

Fig. 41.

exerted upon it at its junction with the cæcum tends to
interfere with the passage of material from it into the cæcum,
while in the latter case this tube is also kinked at the point
in its length where it is fixed by these acquired bands. In
this manner material may be accumulated in the appendix,
and inflammatory processes of varying severity may ensue
producing " appendicitis " (see Fig. 44).

The transverse colon drops. Part of its weight is
transmitted to the convexity of the stomach through the
great omentum, part through the transverse meso-colon to
the spine, and part through an acquired mesentery which

develops between the loops of the transverse colon and the
adjacent surfaces of the ascending and descending colon.
This acquired membrane is evolved in precisely the same
manner as already described, and serves to relieve the
stomach of strain. After a time it opposes the normal
ascent of the transverse colon. Fig. 43 shows the manner
in which the transverse colon drops till it occupies the true
pelvis, interfering with the function of the viscera which
occupy that cavity in normal conditions. The consequent
delay brings about ileal stasis, and, as we will see later,

FIG. 42.   FIG. 43.

duodenal distension, pyloric spasm, and gastric ulcer, which
conditions are shown to perfection in Fig. 41 and Fig. 42.

The cæcum is supported on its inner side by the mesen-
tery of the termination of the ileum and by a portion of
this tube, which practically form an internal ligament of
the cæcum. The strain is exerted upon the shorter under
surface of the mesentery rather than upon the longer
anterior layer.

To meet the increased weight of a loaded cæcum resist-
ances may develop on the under surface of the mesentery of
the ileum over an area of about two or three inches, so that
the inner acquired band helps the mesentery and ileum to
hold up the cæcum.

This mesentery, with those already described and which are identical in origin and causation with it, develop first as whitish streaks, later as bands varying in breadth, and finally as a free mesentery. This being shorter than the
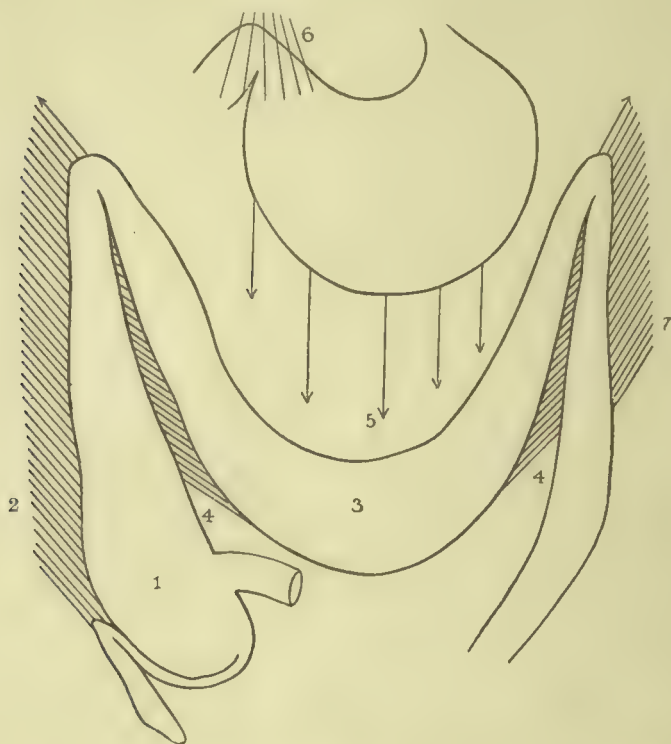
Fig. 44.—1 represents the prolapsed cæcum; 2 and 7 the crystallised resistances which tend to oppose the downward displacement of the large bowel and sustain some of the weight of the transverse colon transmitted through the crystallised resistances 4; 3, the transverse colon; 5, portion of the weight of the transverse colon transmitted through the great omentum to the convexity of the stomach; and 6, the acquired ligament that secures the duodenum and pylorus to the under surface of the liver and gall-bladder.

normal mesentery is attached by its broader extremity to the base of the mesentery and by its narrower limit to the convexity of the bowel opposite the attachment of the mesentery to it. In this manner it kinks and obstructs the
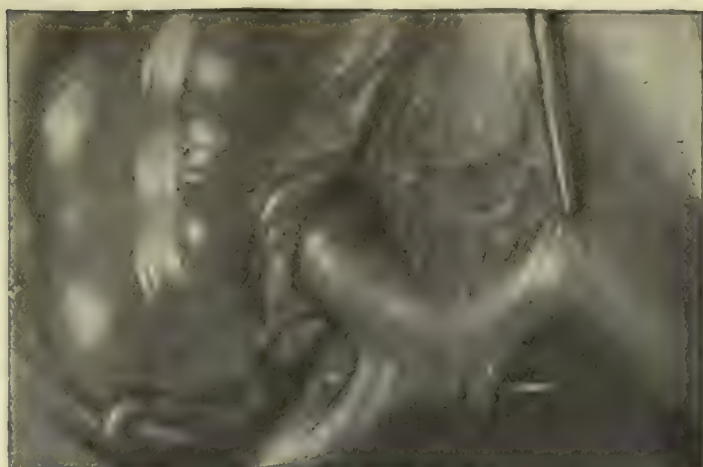
Fig. 45 shows the ileal kink with the band of peritoneum which produces it.

Fig. 46 represents the condition after division of the controlling membrane.
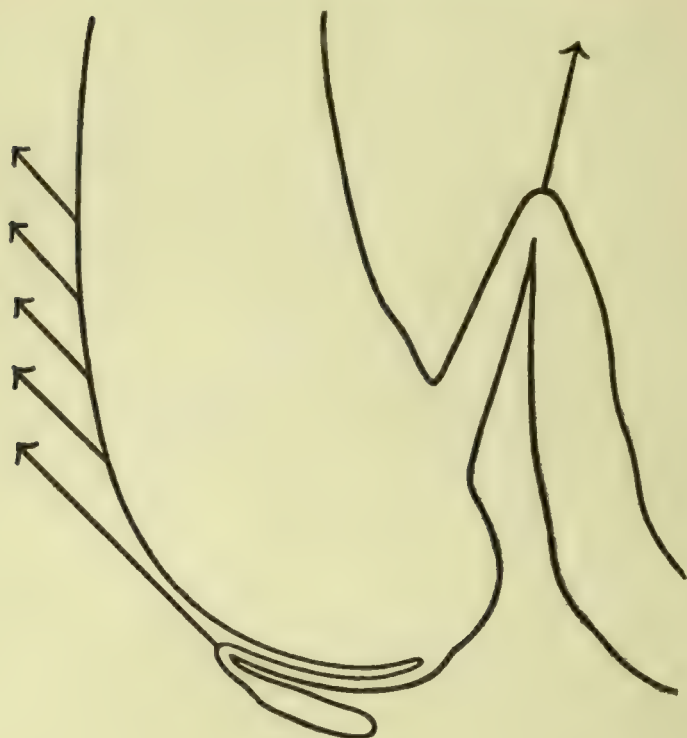
FIG. 47.
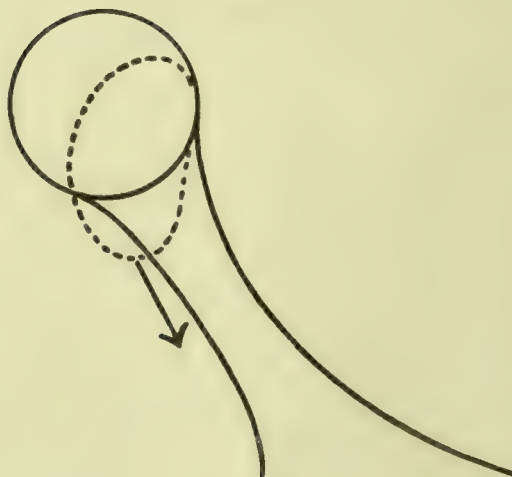
FIG. 48.

ileum in two planes. It produces a sharp angle open downwards when the erect posture is assumed. The attachment to the free margin of the bowel produces torsion around its long axis, so reducing still further its lumen and accentuating its obstruction. This is depicted diagrammatically in Figs. 47 and 48, and Figs. 45 and 46 show Dr. C. J. Mayo's excellent photographs of the acquired band which produces the kink as it exists before and after its division.

Fig. 49.

Some observers regard this band as congenital, but upon no evidence whatever. A peritoneal fold resembles it only very superficially, and I presume that error has arisen in this way.

The degree of its development varies with the occupation of the individual, and is seen to perfection in those whose occupation requires them to stand for long periods in the days. This I have demonstrated to my complete satisfaction.

Again the appendix may be made to play a very

important part as an internal ligament of the cæcum. It becomes attached to the under surface of the mesentery of the ileum by acquired evolutionary bands, which by their contraction have made the appendix taut, especially when the erect posture is assumed, as is shown diagrammatically in Fig. 50, and radiographically in Fig. 49, taken nine hours after the administration of bismuth. The appendix passes upwards and inwards behind the termination of the ileum, and is secured by its free extremity or at some point in its length.

As pointed out before, inflammatory changes may result in the appendix from obstruction produced at two places—one at its entry into the cæcum, and two, at the site of its fixation by an acquired band, should it exist at some point in its length, and not at its extremity. But the appendix acts chiefly as a mechanical control of the ileal effluent, since it produces sharp linear obstruction of the lumen of the small bowel in the erect posture, when both the distal cæcum and the proximal dilated ileum drop downwards into the true pelvis. Superadded to the simple mechanical influence exerted by the tense appendix there may also be the obstruction resulting from the presence of inflammation also in the controlling band.

No results are more satisfactory or more obvious than those which ensue on the removal of a tight controlling appendix. In some cases the obstruction to the ileal effluent may depend to some extent on the co-existence of both factors, namely, the acquired mesentery and the controlling appendix. When one is very marked, the other is always absent, and if one is only slightly marked the other only bears a compensatory mechanical relationship.

It is by no means unusual to have an extreme degree of stasis and prolapse without the organism having made any obvious attempt to obviate the delay by these bands.

These bands illustrate the fact that while the earlier efforts of Nature to help are to some extent efficient and advantageous to the individual, they all finally act to the detriment of the function they were originally intended to benefit.

In very marked cases of stasis these acquired ligaments or mesenteries may be seen at points on the under surface of the mesentery of the small intestine, where they may later do harm by fixing and controlling the effluent in the several loops of the small intestine.

This condition may be so marked as to necessitate the short circuiting or even the removal of a considerable length of the small bowel.

The small intestine, in cases where there is definite local control of the effluent, is generally dilated, and in some cases hypertrophied. The dilation and the hypertrophy are both very evident in the terminal six or eight inches of bowel, and these features are accentuated as the seat of obstruction is approached. In the case of a sharply-defined obstruction due to a tight controlling appendix the line of hypertrophy may end very abruptly and appreciably at that of pressure. If the subject is still fairly vigorous, the bowel is very distinctly hypertrophied, but if the condition is very advanced, the intestine is dilated, its muscle wall is very thin, and it presents a bluish appearance, much as the wasted intestine often shows on the post-mortem table. The pull exerted by the prolapsed small intestines, rendered heavy with their accumulated contents, exerts, through the medium of the jejunum, a strain on the termination of the duodenum. The duodenum usually terminates vertically at the root of the transverse mesocolon, where it is continued into the jejunum as a gentle curve. This I have endeavoured to indicate in Fig. 51. The strain exerted by the jejunum produces a kinking of the duodeno-jejunal junction.

together with a twisting of the commencement of the
jejunum. This causes an obstruction to the effluent from
the duodenum. To oppose this drag upon the jejunum
and the obstruction of the duodenal outlet consequent on
it resistances are laid down as peritoneal bands. These

FIG. 50.

run upwards and outwards from the commencement of
the outer aspect of the jejunum to the peritoneum lining
the adjacent abdominal wall. At first these acquired or
evolutionary bands or ligaments serve a useful and physio-
logical purpose, but after a time, as they contract they
secure the bowel in this vertical position, and no longer
permit it to return to the normal curve in any position
of the body, so that the duodenal outflow is permanently

obstructed, this obstruction becoming exaggerated at times when the patient is exhausted. I have attempted to represent the kinking and twisting of the bowel in Fig. 52, and also to show the situation and direction of the crystal-

FIG. 51.
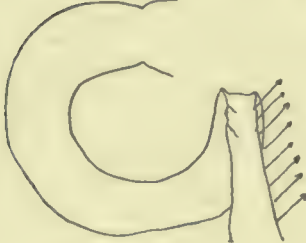
FIG. 52.
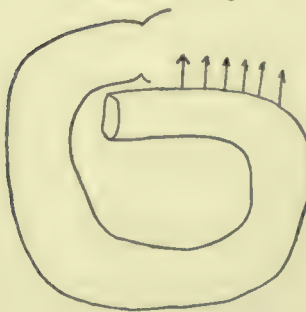
FIG. 53.

lisation of the lines of resistance in peritoneal ligaments or membranes.

It happens not uncommonly that Nature, recognising the importance of avoiding angulation at and strain upon the duodeno-jejunal junction, develops resistances crystal-lised in membrane which fix the jejunal loop so as to avoid kinking. The jejunum becomes secured from left to

right to the under surface of the transverse mesocolon by peritoneal bands of membrane. This I have indicated in Fig. 53. By this means Nature obtains the same result that is arrived at by the surgeon who performs an anterior or posterior gastro-enterostomy for a duodenal ulcer which does not mechanically obstruct the lumen of the duodenum. He simply secures the commencement of the jejunum, so that it cannot fall vertically and continue to obstruct the duodenum. Should the stomach be much dilated he may not even succeed in doing this owing to its continued dropping. In no case does the relief of the duodenal obstruction relieve the obstruction at the end of the ileum, with the consequent stasis and infection of the small intestine, and with the auto-intoxication which results from it.

The obstruction at the duodeno-jejunal junction produces a distension of the duodenum with a dilatation of its lumen and hypertrophy of its wall. This is most marked in the first portion, which is covered by peritoneum and has not the same support from the adjacent structures that the rest of the duodenum possesses. In consequence of the distension of the first piece of the duodenum, and because of the infection of its contents by organisms to which it is unaccustomed, and of the depreciation of its vitality by the general auto-intoxication, changes take place in its mucous membrane which are at first of the nature of vascular engorgement, and later of inflammation of varying degree, till an ulcer may form which may eat its way through the muscular and peritoneal coats. It may heal, cicatrise, and stenose this portion of the bowel. Later, the cicatrisation of the duodenal ulcer produces more or less definite occlusion of the lumen of this portion of the bowel, with consequent changes in the stomach.

Associated with the distension of the duodenum the pylorus develops a varying amount of spasm, obviously to prevent the return of the duodenal contents into the

stomach. This produces a distension and dilatation of the stomach with a varying degree of hypertrophy of its coats. The consequent accumulation of material in the stomach throws a strain upon the lesser omentum at its right limit, and resistances to the downward displacement of the pylorus crystallise as bands or adhesions which connect the pylorus progressively to the under surface of the liver and gall-bladder. An acquired band may extend from the under surface of the liver to the pylorus, which it thus fixes, and by passing on into the transverse colon will tend to secure that structure. Thus, by transmitting its strain directly to the liver, it will free the stomach from a portion of the weight of this part of the bowel. The distended, loaded stomach sustains the greatest strain along its lesser curvature. The strain is greatest near the pylorus, because of the limited area of resistance, and gradually diminishes as it approaches the œsophagus. This latter structure may be regarded as the chief supporting ligament of the stomach in the erect posture. Any descent of the liver brings the strain in the lesser curvature nearer the œsophagus and farther away from the pylorus. The strain exerted upon the lesser curvature of the stomach by the contents accumulated in it is increased by those portions of the strain which are transmitted through the greater omentum to the convexity of the stomach by a loaded transverse colon. In consequence of this strain, assisted by the bacteriological and chemical changes in the gastric contents and by the lowered vitality undergone by the tissues of the stomach, and of the body generally, by auto-intoxication, changes take place in the mucous membrane, which vary from an increased vascularity to a cancerous infection (see Figs. 41, 55, 58, and 76).

To bring about ulceration of the stomach, it is apparent that the mechanism which is responsible for the production of ulceration of the duodenum has superadded to it a

distension of the stomach, with probably much stasis in the
transverse colon.   Therefore, while in most cases recum-
bency relieves the ileal stasis, and consequently the duodenal
distension, and so permits the ulceration of the first part to
get well, in the case of the ulceration in the stomach the
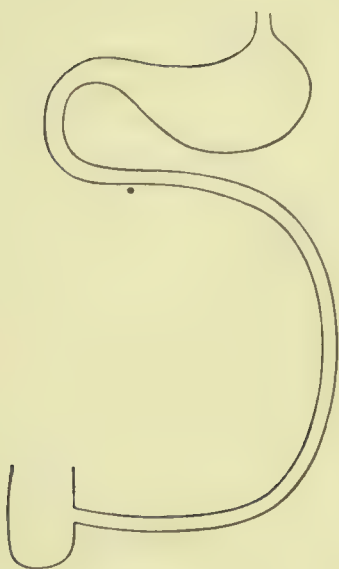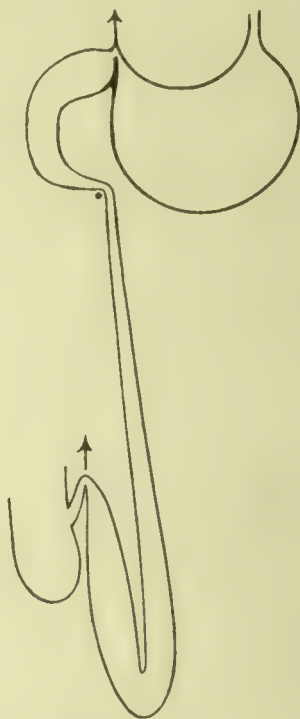
Fig. 54.   Fig. 55.

recumbent position may not cure the stasis nor may it
relieve the pyloric spasm, nor remove the stasis in the
transverse colon.   The explanation of the causation of the
gastric ulcer is also confirmed by the benefit which fre-
quently results from an efficient gastro-enterostomy.   By
efficient I mean one which allows the free passage of gastric
contents in the jejunum.

The rapidity with which the duodenal ulcer can usually

be temporarily cured by position, explains the great rarity of infection of such an ulcer by cancerous germs, while the difficulty of curing gastric ulcers renders them chronic and liable to such an infection.

Fig. 54 is meant to represent, diagrammatically, the normal condition of the stomach, the duodenum, small intestine, and cæcum. The dot indicates the point of resistance at the junction of the duodenum and jejunum.

Fig. 55 shows the changes that ensue in these several structures when the ileal effluent is controlled either by an accumulation of material blocking up the cæcum, by an appendix, or by a band angulating and obstructing the lumen of the end of the ileum in the erect position of the trunk.

Notice the dilated and distended small intestine, the obstructed duodeno-jejunal junction, the duodenum dilated throughout, and more especially in its first part, the spasm of the pylorus, which is held up to the upper surface of the liver and gall-bladder by means of the acquired ligament, already described, the dilated stomach, whose strain is exerted especially on its lesser curve.

These changes are shown radiographically by the following illustrations: Fig. 56 a control of the terminal coil of the ileum taken seven hours after a bismuth meal. The terminal coil is dilated to more than double its normal width. Fig. 57 shows the duodenum and the pyloric portion of the stomach of the same patient taken immediately after the meal. The entire first part of the duodenum (*a*) is greatly dilated, and there is a chronic duodenal ulcer (*ul*) immediately beyond the pylorus. The association between the obstruction of the ileum and the duodenal ulcer is shown with perfect clearness.

Fig. 58 illustrates cancer of the lesser curvature of the stomach grafted on an old chronic ulcer. Here there was marked pyloric spasm and distension of the duodenum, *a*,

b, c.   At this stage of stasis the ileal stasis cannot always

Fig. 56.
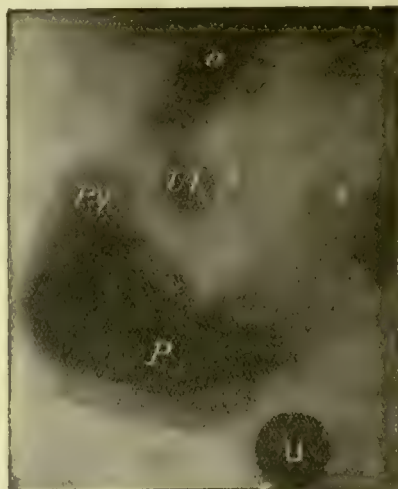
Fig. 57.

Fig. 58.

be so clearly demonstrated because of the very slow escape
of bismuth from the stomach—exceeding seventy-two hours
in this case.

These represent what may be called the mechanical changes that may result from a progressive stagnation in the gastro-intestinal tract, but I would again call attention to the fact that while these bands, etc., develop in consequence of this delay, at first occasionally benefiting and later serving to aggravate more or less severely the delay in the passage of the intestinal contents, a very high degree of stagnation may result from the prolapse of the intestine and from the accumulation of material in it which cannot pass on and which prevents the further passage of fæcal matter into the over-full bowel. All this, with the consequences which are dependent on it, can exist without the presence of any acquired band or controlling appendix.

This is especially clear in the case of the huge, prolapsed, over-distended cæcum, which causes a damming back of the contents of the ileum and jejunum for twenty-four hours or more, with disastrous consequences. Such conditions cannot be so clearly demonstrated on the operating-table owing to the great care that is taken to prepare the patient by emptying the entire tract. Much, however, can be learnt from the X-rays and bismuth meal in the hands of an efficient expert.

Surgeons not finding a definite ileal kink or a controlling appendix, on the presence of both of which they are liable to place too much stress, jump to the conclusion that there is no obstacle to the passage of material from the ileum into the cæcum. Nothing can be more fallacious. This block from accumulation in the cæcum is the most important factor, the ileal kink and controlling appendix being superadded features in a large proportion of cases.

The delay in the ileum in simple stasis (by that I mean stasis in which there is no control of the ileal effluent by appendix or band) may be of very long duration as is shown very well by Fig. 59.

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Fig. 59 shows simple ileal stasis in a woman, æt. 40
years.   Taken thirty-seven hours after a bismuth meal.
Very severe symptoms were relieved by the operation of
" short-circuiting."   There were no ileal bands ; the lower
ileal coils lay limp in the pelvis.

It is obvious that the changes which must ensue in the
delayed contents of the stomach and small intestine must
be very great.

Fig. 59.

The condition of parts in a case of chronic intestinal
stasis on the operating-table differs much more from the
condition which exists during the day-time in the normal
life of the individual than do those presented by varicose
veins of the lower extremity in the same circumstances.

Results of Auto-intoxication on the Tissues.

I will now pass on to consider the consequences which
result from the absorption, chiefly from the stomach and
small intestines, of the products of bacterial or chemical

changes which exist in an abnormal quantity in the material from which the food supply of the individual is obtained. The infection of the food supply is consequent on the damming back of the material in the small intestine and stomach. It would appear that very little poisonous material is absorbed from the large intestine unless there be a superadded infection of its mucous membrane.

This is demonstrated very clearly by the study of congenital dilatation of the colon. Whatever the material is that is absorbed into the circulation in simple stasis very little is known, but if it is present in a quantity in excess of what can be dealt with by the liver, kidneys, and skin, certain very definite symptoms arise which are clearly due to the presence of some abnormal poisonous or deleterious matter in the blood.

Professor Arthur Keith has done a great deal of original work on the functions of the large bowel. The following quotation from a lecture delivered at the Royal College of Surgeons and published in the 'British Medical Journal,' December 7th, 1912, has an important bearing here. The title of the paper is "The Functional Nature of the Cæcum and Appendix":

"Every year the opinion gains ground that the great bowel, from appendix to rectum, has become, so far as man is concerned, a useless and dangerous structure. Exactly ten years ago (October, 1902) Dr. Barclay Smith, of Cambridge, gave a clear expression of this new conception.

"'If there is any truth,' he wrote, 'in the suggestions offered in this paper, they have an important practical application as regards the large intestine of man. From the nature of his diet a reliance on extrinsic digestive aid as is furnished by bacteria is no longer a physiological necessity. The statement is perhaps a bold one, but I am convinced that the large intestine is practically a useless encumbrance to him.'

" In the following year (1903) appeared Metchnikoff's famous book on 'The Nature of Man.' In that work (p. 69) the new conception received a more decisive statement :

" ' It is no longer rash to say that not only the rudimentary appendix and the cæcum, but the whole of the large intestine are superfluous, and that their removal would be attended with happy results.'

" Before either of these statements had been made, Mr. Arbuthnot Lane had reached the conclusion that the human cæcum and the ascending colon served, in a certain class of cases described by him, as a 'cesspool,' and put his new conception into practice either by excluding the great intestine from the digestive tract by 'short-circuiting,' or, at a later date, by its complete excision. The result of his operations shows (1) that life is possible without a great intestine ; (2) that in certain cases the conditions of life are improved. It is very apparent that Mr. Lane's pioneer operative measures are finding every year an increasingly wide application, and that the views of Metchnikoff and of Barclay Smith are gaining in acceptation amongst medical men."

I need hardly remind you at this period of the remarkable confirmation of my views by Carrel's magnificent work in the Rockefeller Institute on the growth of tissues, and would simply repeat his statement that living tissue is immortal, providing it is properly nourished and effectually drained. I have recently seen him establish the same principle on a larger scale. He eviscerated a cat and so arranged the drainage of the intestine that it continued to perform its function normally during artificial respiration for a period of about ten hours. He hopes by preventing the death of the organs by peritonitis to prolong their life for a much longer period still. The improvement in the growth of tissue which he obtains by attending very

carefully to the drainage is exactly paralleled in the great and very rapid increase in the growth and weight of patients after the large bowel has been excluded from the gastro-intestinal tract. We all recognise how much we owe to the intelligence of this remarkable man, particularly as regards the study of chronic intestinal stasis and its consequences.

Carrel's observations are of the greatest service at the present moment since they afford us the same confidence in our method of treatment of intestinal stasis that X-rays did in the operative treatment of simple fracture when the opposition to that form of treatment was intense, and to a great extent unscrupulous in its method.

The first result of auto-intoxication to which I would call your attention is the removal of fat, which is a marked feature in most cases and is, perhaps, the first evidence that the individual is failing in capacity to deal with the poisonous matter that is destroying the structure and impairing the function of every one of the component tissues of the body. This brings about not only an appearance of premature senility, but also a series of changes of infinite importance to the individual, and especially to the female, in whom, for reasons I have already indicated, fat plays a far larger share in supporting important organs and structures than it does in the male.* The changes in the position of the several organs which follow on the loss of fat serve to exaggerate the existing stasis in the gastro-intestinal tract and to produce a vicious circle. The removal of the pelvic fat results usually in a backward displacement of the fundus of the uterus, which rests upon the concavity of the rectum. When the woman strains to evacuate the contents of the rectum she drives the large gorged fundus vertically downwards and the rectal lumen

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* " What are the Chief Factors which Determine the Differences which exist in the Form of the Male and Female Pelvis," 'Trans. Obstet. Soc. Lond.,' 1887.

is compressed between it and the sacrum, or, much less
frequently, the uterus may be bent forwards, partly on
account of the loss of fat and to a large extent because of
the degeneration of its muscularity which exists generally
throughout the body.   Consequent on the engorgement and
the displacement or kinking of the uterus, a number of
changes take place in that organ which call for the atten-
tion of the gynæcologist. As we shall see, auto-intoxication
plays so large a part in the development of diseases of the
female genito-urinary apparatus that the gynæcologist may
also be regarded as a product of intestinal stasis. If women
were not imperfectly drained the gynæcologist would not
have been evolved.

Mr. Harold Chapple, who has for many years devoted
much time to the study of these cases, first from a surgical
and then from a gynæcological standpoint, has on several
occasions drawn attention to the great importance of chronic
intestinal stasis as a primary factor in the production of
many gynæcological conditions, to which he calls attention
in the following publications.*

The removal of fat from the true pelvis permits of the
greater descent of the cæcum and small intestines into that
cavity and exaggerates the obstruction of the ileal effluent
correspondingly.

The kidneys move freely in the space behind the peri-
toneum, in which they were originally supported by a
cushion of fat, and changes ensue in these organs should
the escape of blood or urine from them be controlled by
their altered relationship to adjacent structures.

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* " Chronic Intestinal Stasis treated by Short-Circuiting and Colectomy,"
' Brit. Med. Journ.,' 1911. " Some Cases of Advanced Tubercular Hip treated by
Ileo-Colostomy," ' Lancet,' 1912. " The Fundamental Facts of Chronic Intestinal
Stasis," ' International Journal of Surgery,' April, 1914. " Some Effects of Chronic
Intestinal Stasis on the Female Generative Organs," ' Brit. Med. Journ.,' January,
1914. " Chronische Darmstase behandelt mittels Kurzer Zirkulärer Umschneidung
oder Kolektomie," ' Berlin Klin. Woch.,' April, 1911.

As regards the attractiveness of the woman, a matter of vital importance to her happiness, the loss of fat is a most serious factor. The formation of wrinkles, the prominence of bones, etc., are all most distressing and conspicuous features. The buttocks also become flat and flaccid, instead of firm and round, partly because of the disappearance of fat which enters so largely into their formation, and partly because of the associated degeneration of the large gluteal muscles. The breasts also waste and flop downwards, and the whole form and contour of the woman alters conspicuously in the most objectionable manner.

The skin undergoes remarkable changes and affords, perhaps, the next most obvious evidence of the degenerative changes which are going on all over the body. It becomes thin, inelastic, sticky, and pigmented, especially where it is exposed to any pressure or friction. This pigmentation is observed first in the eyelids, whence it spreads gradually over the face. The neck becomes brown and later almost chocolate-coloured. The skin of the axillæ, abdomen, adjacent aspects of the thighs, and that covering the spinous processes of the vertebræ, becomes progressively darker and darker, and defined areas of even darker pigmentation may develop on these stained surfaces. The secretion from the flexures also becomes abundant and offensive. In some of the cases I have operated on this symptom has been such a marked feature as to render the patient very objectionable to others.

The hair of the head falls out, either because of impaired nutrition of the cells or from the invasion of the roots by organisms. In the young subject, associated with this is a new growth of a fine down over the cheeks, lip, chin, down the back and over the forearms, all of which conditions are very disfiguring and very distressing to the sufferer. These all disappear, more or less completely, with an improvement in the drainage.

Here I would like to call attention to the extraordinary variation in the resisting power of the individual as manifested by the colour of the hair, not only to the changes in the fat and colour of the skin already referred to, but to all other consequences of auto-intoxication. The darker the hair the lower is the resisting power to auto-intoxication and the more conspicuous are the changes which result from it. On the other hand, if the hair is red or of a peculiar towy colour, the individual has a maximum of resisting power to the action of these poisons, and that resisting power varies directly with the distribution and with the intensity of the redness of the hair. This is manifested very conspicuously in the influence exerted by the toxins on the appetites of the individual. The darker-haired subject will loathe sight of food and frequently abhor any sexual relationship, while the red-haired subject rarely manifests these effects, even in the extreme conditions of intestinal stasis. This influence of toxins on the normal appetite is of far-reaching importance in our present state of civilisation and is the source of much misery, discontent, and trouble, to which I will not do more than allude here.

Some time ago I called attention to the influence prostatic secretion exerts in combating the effects of auto-intoxication. I pointed this out to Metchnikoff, who thoroughly agreed with me on the subject, and afforded me additional confirmation of its truth by the results of experiments on the action of prostatic fluid upon spermatozoa. To attempt to meet this condition Messrs. Armour make, in their works in Chicago, an extract obtained from the prostates of rams, and this has been administered very generally and apparently with marked benefit.

Other changes in the skin are those dependent on a damping down of the heart's muscle by the toxins, and upon a breaking up of the red corpuscles, which is called

in the most marked condition "microbic cyanosis." The
limbs become very cold and this coldness becomes exag-
gerated as the extremities are approached. If the hand be
passed over the shoulder it crosses abruptly from an area
of warmth to one of comparative coldness. This corre-
sponds to a line drawn transversely round the centre of the
deltoid. The skin of the back of the upper arm is very
thick and feels as if it were affected by a firm, brawny
œdema. Its colour is bluish and in some cases even livid.
It is liable to be covered with hard, pointed papules. This
condition exists to a much more marked degree in the girl
than in the woman, and may be sufficiently conspicuous to
render the wearing of short sleeves impossible. The skin of
the forearm and hand is mottled, being bluish and yellow in
patches, while the fingers may be quite blue or cyanotic.
The legs present the same condition and usually in a greater
degree. The patient frequently complains that she has no
feeling up to her knees even in moderately warm weather.
These people are better in warm weather and in fairly high
altitudes, and are always worse in the cold, and by the sea.
In some cases the condition is so marked as to constitute
Raynaud's disease in all degrees of severity.

The muscular system degenerates in a very marked
manner. The voluntary muscles waste and become soft,
and in advanced cases tear with the greatest facility. In
consequence the individual assumes positions of rest. In
young life the muscular debility produces the deformities
which are called dorsal excurvation or round shoulders, but
which are more scientifically described as the "symmetrical
posture of rest of the trunk," lateral curvature or scoliosis,
which is better designated as "the asymmetrical posture of
rest of the trunk," flat-foot, and knock-knee. These con-
ditions are still further exaggerated by pressure changes in
the epiphysial lines. To subject these cases to exercises or
to fix them in apparatus without also removing the primary

factor in their causation, namely, auto-intoxication, is of little service.

The relaxation of the muscle-wall of the abdomen deprives it of its function of compressing the viscera efficiently in defæcation, and results in the accumulation of fæcal matter in the pelvic colon.   This elongates proportionately and renders the evacuation of its contents more and more difficult.   The abdominal muscles cease to exert upon the several viscera that firm pressure which is requisite to keep them in their normal relationship to the spine and to each other, and the errors in drainage become further accentuated. The normal mechanical disadvantages of the female abdomen render these changes much more conspicuous than in the male subject.   As I have already pointed out, the uterus suffers in the same manner, so that it flops or bends about in response to gravity and intra-abdominal pressure, and much trouble in it and in other structures ensues in consequence.

The muscular wall of the intestines wastes in a similar manner, so that in an advanced case of stasis the ileal wall is very thin and bluish or livid in colour, resembling the appearances seen at a post-mortem, and they give out a distinctly earthy or fæcal odour.   The intestine has no rounded form, but, being inelastic, puddles like jelly in the floor of the true pelvis, forming innumerable bends, through which its contents are transmitted with great difficulty.

The heart-muscle is influenced by the poison in the same manner.   Here, however, we get two distinct conditions arising, varying, I believe, with complications in the most important excretory organ—the kidney—as well as in the circulatory system itself.   In one group of cases the heart is soft, flabby, and the blood-pressure subnormal; while in the other the left heart is definitely enlarged, the aorta dilated, and its walls atheromatous, as are those of all the vessels, and the blood-pressure is abnormally high.   I am

greatly indebted to Dr. Jordan for demonstrating most clearly to me the changes in the heart and aorta in this class of case. Fig. 77 illustrates atheromatous degeneration of the aortic arch, showing the resulting elongation and dilatation in a typically static subject. Generally speaking, the soft heart and low blood-pressure are more common in the female subject, while the enlarged heart and high blood-pressure are more frequently observed in the male. Inflammatory or degenerative changes in the kidney are much more commonly associated with the second group than with the first.

If, unfortunately, the patient is the subject of syphilis, the combination of this disease with auto-intoxication produces an extreme degree of change in the wall of the large vessels, and especially in those of the trunk.

Dr. James Mackenzie has recognised and described the heart changes consequent on auto-intoxication so thoroughly in his work on the subject that any further reference to them by me is unnecessary. I would merely add that the normal degree of blood-pressure is soon restored to the patient when the large bowel is excluded by operation.

The toxins appear to exert a special depreciating influence upon the respiratory centre. How far this is produced in the nervous centre, and how far it results from a degeneration of the respiratory muscles, is very difficult to determine. Symptoms which are typically asthmatic in character are not infrequently seen in this condition, while minor varieties are commonly present.

The toxins exert upon the nervous system a most distressing and depressing effect. This is perhaps the worst feature of the effects of chronic intestinal stasis. The patient is usually miserable. Sometimes the depression and misery is so great as to constitute melancholia or imbecility. Several of my patients have attempted or contemplated suicide, and they or their medical-attendant have used the

intention to do so to induce me to operate on them.
Indeed, one hopeless person blew his brains out while we
were arranging for his admission into a home. As far as
insanity is concerned, it is hard to say how much is due to
auto-intoxication and how much to primary trouble in the
brain. On this subject Dr. Maurice Craig has afforded me
great help.

A marked incapacity to perform any mental or physical
exertion is a common feature of the condition. This is not
only a cause of great distress to the patient, but it
frequently entails considerable financial loss. Occasionally
it prevents the sufferer from following any employment.

These patients suffer frequently from headache, varying
in intensity from a dull ache to a pain that is intolerable.
In one case, owing to the pain and vomiting, a tumour in
the brain was diagnosed by a famous expert in brain con-
ditions, and an operation was advised. The pain and
vomiting both disappeared immediately after an ileo-colo-
stomy with colectomy.

Sleeplessness and bad dreams are complained of not
infrequently, but in many cases the patient sleeps very
soundly and awakes with a distressing sense that no rest
or benefit has ensued from the sleep. Some patients fall
asleep during the day with the greatest readiness.

The favourite "diagnosis" for these cases of auto-
intoxication, in which the nervous system suffers in a
marked manner, is neurasthenia. They used to be treated
by rest in the supine position, massage, and feeding. By
all these means the effluent from the ileum was improved
and fat was put on. The patient derived a fleeting or
more or less permanent benefit from the treatment, which
varied with the extent of the infection of the dammed-back
contents of the ileum. So-called neuritis is a frequent
complication. It varies commonly in severity, from violent
epileptiform tic to sciatica of a mild type. Often the pains

are described as rheumatic in character, and it is difficult to say in what particular tissue the pain originates.

The breast behaves in a characteristic manner in auto-intoxication, so much so that it may be regarded as the barometer of the degree of poisoning. At first it presents induration, which commences in the upper and outer zone of the left breast, extending subsequently to the entire organ on both sides. Cystic or other degenerative change may ensue, and at a later period cancer appears with remarkable frequency in these damaged organs. I have found as many as seven distinct nodules of cancer in a hard, lumpy breast in which the presence of that disease was not suspected. One of the most remarkable results of removing the source of auto-intoxication is the rapidity with which even extreme degrees of degeneration of the breast disappear, and the organ regains its normal form and texture after operation on the intestine.

The thyroid gland diminishes steadily in size, and in an advanced case it may be so small that the finger can detect no evidence of its presence. How far the supra-renal glands degenerate in the same way I do not know exactly, but I think from the few observations I have made that it is probable that they behave in much the same manner as the thyroid.

The eyes show very definite evidences of degeneration, in support of which Mr. Ernest Clarke produced a large quantity of confirmatory evidence on the occasion of the discussion on what they were pleased to call "alimentary toxæmia" at the Royal Society of Medicine, the more appropriate term "chronic intestinal stasis" not at that period having acquired the popularity it has since arrived at.

The joints of toxic people, and especially of children, are very loose and permit of considerable over-extension. We know that the fit or security of a joint varies directly

with the development of the muscles which control it, and the feebleness of the poisoned muscles readily accounts for the insecurity of the joints. The mobility of the joints gives a very clear idea of the date of origin of the stasis.

INFECTIVE CONDITIONS.

We will now consider the conditions or so-called diseases which arise in the individual because of the lowered vitality of the tissues by the presence of toxins or poisons in the blood.

Many of them are known to be due to organisms, but in others their origin is unknown.

This invasion of the tissues by organisms, etc., is seen very early in life.

Infections of the mucous membrane of the naso-pharynx with the lymphatic tissue in this region are readily recognised, and are manifested chiefly as adenoids and large tonsils. Later, changes develop in the sinuses communicating with the naso-pharynx and in the middle ear.

The glands in the neck also become affected, in the first instance by one class of organisms, but later their still further depreciation affords in them an excellent nidus for the tubercle bacillus, which once it effects an entry is very difficult to eradicate. These secondary manifestations of stasis produce cumulative symptoms and add their share to the depreciation of the vitality of the tissues.

In these toxic people the organisms which exist normally in the mouth are able to secure a foothold in the interval between the teeth and the gums, and manifest their presence as an infective or inflammatory process. This extends deeper and deeper into the socket, and results in the loss of the affected teeth. The process usually commences, as one would expect it to do, about the lower incisors. As a quantity of organisms is grown in these

nurseries, the absorption of their products into the circula-
tion, gastro-intestinal tract, and respiratory apparatus all
assist in the general process of depreciation. Many
observers are inclined to regard these secondary foci as
primary, since a marked improvement in the general
resisting power may result from their effective treatment.
A little consideration shows the absurdity of this supposi-
tion. In a considerable proportion of the patients who
are driven to operation by the results of intestinal stasis,
in all, or almost all, the teeth have been previously removed
for this reason. The removal of the teeth has not relieved
the symptoms of the stasis, which was the primary factor.
In a smaller proportion there is no evidence whatever of
infection of the gums. This is usually the case in those
who have small teeth, and who devote much care to the
cleanliness of their teeth. Again, however bad the con-
dition of infection of the gums may be at the time of
short-circuiting, an immediate and extraordinary improve-
ment in this disease follows on the cleaning up of the
small intestine.

The direct extension along the pancreatic and common
bile ducts of infection from the stagnating contents of the
duodenum results in induration and inflammatory changes
in the pancreas and later in cancer. The following radio-
grams show clearly the association between both diabetes
and cancer of the pancreas and chronic intestinal stasis.
Fig. 62 shows stasis in a prolapsed and twisted transverse
colon in a diabetic forty-seven hours after bismuth, which
remained practically unchanged for ninety-five hours. This
patient had previously suffered from exophthalmic goitre.
Fig. 61 shows the terminal coil of her ileum tortuous and
firmly fixed in the right iliac fossa. After twenty-three
hours the lower ileal coils were still well filled with
bismuth. Fig. 60 shows the duodenum of the same patient
very much dilated. Strong writhing peristalsis was

Fig. 60.

Fig. 61.

Fig. 62.

Fig. 63.

observed. The stomach showed active peristalsis with marked pyloric spasm. She unfortunately died of diabetic coma before any operation could be performed. The association between cancer of the head of the pancreas and ileal stasis is demonstrated clearly by Fig. 63, which shows more than ten hours delay in the ileum with a marked ileal kink. In the case of the liver gall-stones develop in the gall-bladder, and they, by their presence in the gall-bladder or in the ducts, produce additional infections and, in a fair proportion of cases, cancer. It is probable that many of the diseases of the liver result from infection of its ducts, or from overwork, its tissues being devitalised by the presence of a large amount of toxins in the blood nourishing them.

I would like here to express my great obligation to Dr. Jordan for the very valuable assistance which he has afforded me during the several years that I have had the advantage of his help in verifying the several hypotheses which I formulated from time to time. Much of his success was due to the fact that he made a point of being present at every operation, by which he was enabled to criticise any fault in his technique, and to find means of overcoming the several difficulties that presented themselves from time to time. I am indebted to him for all the radiograms which illustrate this paper.

In women who are toxic the infection of the genital tract is an extremely common and distressing feature. It manifests itself usually as an infection of the mucous membrane and muscle of the uterus, and is called endometritis or metritis. The continued presence of this infection brings about many troublesome consequences, the last link in the chain being here, as elsewhere in the body, cancer. Cancer is the last chapter in the three-volume story of " Chronic Intestinal Stasis." The bladder of the toxic woman is also very often infected by organisms.

Fortunately, the extension of organisms from the bladder to the kidneys is not as frequent as one would expect, yet it is quite common enough to produce much disease of these organs and to involve the patient in great risk during pregnancy. Bacilluria may be a very serious condition and capable of causing very great anxiety. The urinary apparatus in the male is also affected, especially in early life.

I do not think I need call the attention of the obstetricians to the important part played by pregnancy in relieving the disabilities of the drainage scheme. The ascent of the uterus in the abdomen serves to raise the portions of the drainage scheme which have prolapsed, to tend to stretch retaining bands, and to improve materially the effluent from the ileum, etc. If, however, an ileal kink be a very marked feature, the pressure of the uterus upon it may exaggerate very materially the obstructive symptoms that existed previous to the pregnancy. Consequent on the former and more fortunate occurrence, the woman puts on fat, which pillows up the several organs, and tends to obviate their subsequent prolapse. It is in this manner that a toxic, thin, miserable girl may be converted into a plump, clean, happy one by a pregnancy. It would seem almost justifiable in an unmarried girl in certain circumstances to resort to a pregnancy rather than to operative interferences. This course has, however, distinct and obvious objections in our present state of civilisation.

That the skin, depreciated in vitality and in resisting power, becomes invaded by various organisms, which produce many of the diseases of the skin, is familiar to us all.

The most common affection is perhaps the formation of pustules on the face and body, which is a great source of disfigurement and distress to the sufferer.

The presence of tubercle in the body, except by direct

inoculation, is, I believe, always preceded by that of auto-intoxication.

In the case of the intestine, the disease commences at the termination of the ileum immediately about the seat of control. It may manifest itself solely, as in infection of the glands in the mesentery, in the angle between the ileum and cæcum, or it may have associated with the glandular enlargement a number of ulcers which extend upwards at intervals along the small intestine.

The glandular infection may be the chief feature, and may be sufficiently extensive as to occupy nearly, if not all, of the mesentery, and apparently to control the entire lymphatic supply of the small intestine.

Associated with this intestinal infection or independently of it, tubercle may be present in the mediastinum, lungs, or other parts of the body. Tubercular infection is, unfortunately, so frequently not a pure infection, but is aided in its destructive power by a variety of other organisms.

Rheumatoid arthritis, like tubercle, is never present except in association with auto-intoxication due to chronic intestinal stasis. Its severity may be accentuated by the presence of any other infection which exists in consequence of the stasis, such as infection of the uterus, gums, nasal and associated sinuses, etc., and some relief to the severity of the symptoms may be obtained by dealing with these secondary infections.

Still's disease is another illustration of the invasion of the body when vitality is lowered by chronic intestinal stasis.

The thyroid is liable to various infections which cause the several forms of disease of that organ, such as exophthalmic goitre, general hypertrophy, the development of adenomatous tumours, of cysts, and finally of cancer. None of these conditions can arise except in the presence of intestinal auto-intoxication.

The same applies to the suprarenal glands where the degenerating gland becomes the seat of tubercle, or, even without the presence of this disease, is so devitalised that its functions are more or less in abeyance, and Addison's disease develops in varying degrees and intensity.

Other secondary infections are those of the large bowel, which produce the several varieties of so-called colitis, membranous colitis, and ulcerative colitis.

Last of all, there is the infection by the organism or whatever it is that determines the development of carcinomatous change in the tissue, whose resisting power has been depreciated by auto-intoxication.

There is an innumerable number of secondary infections to which I might call attention, but these serve to illustrate my point sufficiently clearly.

The Treatment of Chronic Intestinal Stasis and of its Consequences.

The treatment of so-called indigestion, which represents the first few chapters in the first volume of chronic intestinal stasis, has for long been most unsatisfactory. In my student days indigestion was regarded as something quite beneath the notice of a hospital physician, and if the unfortunate clinical clerk sent such a case in to see him he was informed that he should not dare to do so in future, but that he should give some such material as soda and ginger, or some bismuth salt. The admission of a constipated patient was an even greater crime. I do not say that this feeling was universal among physicians, but merely retail my personal experiences. Physicians were then only interested in what were called good cases, or, in other words, patients who were very ill.

The reason of all this was obvious. All that was known about pathology was learned from the wreckage of the

human frame as it could be seen on the post-mortem table, and from this the pathologist endeavoured to learn something about the end-results. It was, obviously, as hopeless for him to obtain any information about the primary causes as it would be for an average person to determine the origin of a fire by examining the ruins.

That explains the hopeless position of the physician in regard to indigestion and its sequelæ. Nothing was done till the end-results which ensued, either directly or indirectly, from the defective drainage appeared, and these were split up into those that appeared unlikely to recover or were not amenable to operative interference, which were regarded as purely medical, and those which gave the surgeon an opportunity of dealing with them by some surgical measure.

In consequence of this, surgery and medicine were resolved into what I call treatment of end-results. That meant that a large number of drugs were employed by the physician to treat symptoms, while the surgeon expended much thought and ingenuity in devising methods by means of which he could cure or alleviate the conditions he regarded as surgical.

I believe the whole principle involved is wrong from start to finish. We have got to investigate primary causes, and to study their relationship to so-called disease. Let us consider the more simple conditions of the gastro-intestinal tract, as distinct from the consequences of stasis.

How are these cases treated? They are given germicidal drugs, which appear to me to act by diminishing the number and virulence of the offending intestinal organisms. I refer to such medicines as arsenic, iron, mercury, etc. Or they are supplied with organisms which are intended to antagonise the growth of deleterious organisms in the intestine, or vaccines of these organisms are injected into

the circulation to effect the same purpose. I do not for
one moment wish to suggest that the treatment of many of
the end-results of chronic intestinal stasis, especially of the
more acute conditions, is not most useful when employed
by a competent bacteriologist; indeed, in many cases no
other treatment is, as far as I know, of any avail. Or they
are given increasing amounts of more or less irritating sub-
stances called purgatives, with the object of hastening the
passage of the contents of the intestine, and so affording
less time for infection of the contents by organisms and for
the absorption of their products. Or they are cut off the
use of foods which decompose readily and produce poisonous
material. Or they are given large quantities of water, to
wash away as rapidly as possible the poisons that have been
absorbed into the circulation and tissues. They are
massaged and exercised in order to stimulate the intestinal
contents to move on. They have their stomachs washed
out when material is dammed back and decomposes, and
they have the large bowel flushed by abundant quantities
of water, frequently containing antiseptic or irritating
material.

This represents the medical treatment and the essence
of the so-called "cures," which frequently effect a tem-
porary alleviation of symptoms. All these forms of treat-
ment are tedious, dangerous, and at the best only palliative.

From the surgeon's point of view the treatment of
chronic intestinal stasis consists in facilitating the passage
of material through the several portions of the gastro-
intestinal tract, and so obviating the mechanical and
chemical results of any fault or faults which may develop
along its length consequent on the peculiar mechanical
relationship of the individual to surroundings as involved
in the complex conditions of the civilisation of the present
day. In the vast majority of cases the use of a lubricating
material, such as pure liquid paraffin, which precedes the

passage of food, the application of some spring support to the lower abdomen which tends to keep the prolapsed viscera up and to control the delay of material in the small intestines and cæcum, supplemented by massage or any efficient means by which the muscles of the intestine and of the abdominal wall can be developed, and the avoidance of the use of such proteid foods as poison the tissues if retained for an abnormally long time in the intestine, are sufficient for the purpose. When these methods fail resort must be had to operative interference. The essential object of such operative treatment is to facilitate the effluent from the ileum, and so to remove at once from the drainage scheme the stagnating material from which toxins, etc., are chiefly supplied.

I take it that before submitting a patient to any surgical risk whatever it is our duty to employ every scientific means at our disposal to determine exactly what is wrong, remembering that a so-called exploratory operation on the intestinal tract is of little value, since it is performed on a drainage scheme which has been previously thoroughly emptied of its contents by means of powerful purgative drugs and enemata. That is the reason why an exploratory operation only too often ends in the removal of an anchored appendix, a result that appears to satisfy the ambition of the surgeon, and the curiosity of the patient and the friends. I trust that this phase of surgery is rapidly passing away, together with the obscurity that was associated with the medical treatment of the results of chronic intestinal stasis.

As I have pointed out, the measures to be undertaken to free the ileal effluent depend entirely on the nature of the mechanical conditions which produce the stasis, and also on the state and circumstances of the patient at the time. For instance, where the ileal effluent is controlled by an appendix which is hitched up behind the termination

of the small bowel, the removal of this constricting structure frees the lumen of the small intestine, and restores it to its normal function more or less completely. At the same time, if, in consequence of the stasis, there are present marked rheumatoidal or tubercular changes or other secondary infection, the acceleration of the passage of the contents of the altered and dilated small intestine into the cæcum may not so effectually clear the small intestine as to afford the sufferer sufficient spare energy to deal with the disease. This is probably due to the existence of enough delay in the large bowel, together with old standing dilatation and stagnation in the small bowel, to prevent the free or normal evacuation of the latter. In these circumstances the only effectual way of establishing perfect drainage is ileo-colostomy with or without colectomy.

The same applies with much greater force to the control of the ileal effluent by the acquired membrane which produces the ileal kink, to which American surgeons have attached my name. This form of obstruction is much more serious than that which is brought about by the appendix, since it is very liable to re-form, whatever means are adopted to obviate its recurrence. This is especially the case if the individual is obliged to continue the occupation which was very largely responsible for its development in the first instance. Obviously, such a recurrence of the obstruction cannot arise when the appendix is the controlling medium. Also, for some reason or other, the free division of these bands and membranes occasionally results in the production of a peritonitis which may cause serious anxiety. This is possibly due to the division of lymphatics which have developed in and about the acquired membrane, and, draining a fouled area, are likely to possess sources of infection in the material which they carry. Consequently, when the ileal kink is produced by

any extensive arrangement of acquired bands, especially in the female subject, I prefer to perform colectomy rather than to merely divide the constricting bands. I believe that in many cases the risks of colectomy are less than those of division of the band, while the possibility of recurrence by their re-formation is permanently removed. The necessity of following the same occupation which determined the obstruction originally makes such a procedure all the more advisable. The convalescence after colectomy is also much more satisfactory than that which follows the division of bands, while the advantage which the patient derives from the more radical operation is infinitely greater, and the subsequent improvement is progressive.

It will be well to remember that, while the surgeon should not have recourse to operative measures till all simpler treatment has failed, the earlier colectomy is performed in the history of the disease the better is the result. The youngest patients get by far the most out of the operation. As the sufferer approaches the end of her career the benefit from this operation becomes correspondingly lessened.

There are some conditions of volvulus in which the surgeon may with advantage do no more than remove the volvulus, but, as in the case of growth of any mobile portion of the large intestine, I prefer, if circumstances will permit, to remove the entire large bowel, except a sufficient proportion of the pelvic colon. This applies also to all cases of so-called mega-colon.

I say if circumstances permit, because we are often called on to perform operations in surroundings and with assistance which do not justify us in doing the best possible.

Of the advantage of this radical procedure, namely, colectomy, I have not the least doubt. The two chief

reasons in its favour are that it is usually much easier and safer to do a colectomy than to remove a part of the large bowel, and the benefit that results from the colectomy is enormously in excess of the partial resection.

In the case of growth recurrence is minimised by this procedure. I have seen many patients die or make a tedious and unsatisfactory convalescence because the surgeon wished to resect a portion of the length of the bowel, who, I am certain, would have recovered if a complete colectomy had been performed.

In cases of acute obstruction due to a growth in the large intestine, considerable distension of the bowel proximal to the growth facilitates in a remarkable manner the removal of the bowel, and also eliminates a large quantity of decomposing fæcal material as well as acutely inflamed intestine. Colectomy also enables the surgeon to drain the small intestine at once by means of the tube passed up into it through the ileo-colic junction, and so to free the drainage scheme from its poisonous contents effectually and the tissues of the body from their baneful influence.

While one is of necessity guided in one's practice by general principles, circumstances and the peculiarities which each case presents must influence our treatment very materially.

Now, as to the operation of colectomy, which I prefer to perform rather than ileo-colostomy in the large majority of cases, it is one that varies greatly in the facility or difficulty with which it can be carried out. There are two mechanical extremes calling for colectomy, one being in a wasted woman whose entire large intestine has a long, loose mesentery, and in which Nature has made no attempt whatever to crystallise resistances to oppose the prolapse of the bowel. In these circumstances the large bowel is removed with the greatest ease and without a moment's anxiety.

In the other extreme, Nature has made every possible effort to obviate the downward displacement of the viscera, and the bands have kinked and controlled the lumen of the large bowel at many points.

In such a case the facility with which the operation can be performed depends on the surgeon being thoroughly familiar with the mode of development and the arrangement of the acquired bands. If he has not the requisite knowledge he ties the mesenteries, both original and acquired, *en masse*, and makes what is really a comparatively easy and safe operation a difficult and dangerous one. This applies particularly to those acquired bands controlling the splenic flexure.

In these circumstances it is necessary to separate the acquired bands from the mesentery, ligaturing any vessels that may have developed in them. Small vessels exist not infrequently in the bands about the splenic and hepatic flexures, and about the cæcum and in the situation of the last kink. By first dealing with the acquired bands the ligature of the true mesentery, which is restored to its normal length, is effected with a minimum of risk of hæmorrhage, and less raw surface is left exposed to which portions of small intestine can become attached. I believe it is due to this difficulty that many surgeons are satisfied to remove the cæcum, the ascending and the greater part of the transverse colon, and to connect the end of the ileum with the end of the transverse colon. I did this on one or two occasions, about thirteen or fourteen years ago, but found that the obstacles afforded by the splenic flexure and the last kink rendered it inefficient and unsatisfactory, only a partial improvement following the operation. The danger from hæmorrhage is a very real one if there be much fat in the mesenteries, or if the tissues be friable, as they not infrequently are when the disease is advanced. Consequently the greatest care should be taken to tie each

ligature with sufficient force to ensure the occlusion of the arteries contained in it.

Personally, I prefer to divide the mesentery beyond the ligature before tightening the tying of the knot, so that the ligature bites well into the mesentery after it has been deprived of blood.

As to the preparation of the patient, the thorough evacuation of the intestines, preferably by castor-oil, is of great importance, since the more empty the small intestines

SCALE ½

ALLEN & HANBURYS
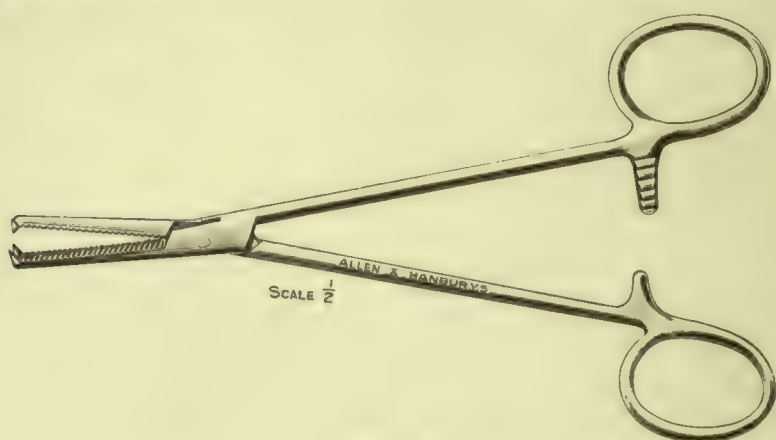
FIG. 64.

the more easy is the operative procedure. Nothing adds more to the risk of the patient and to the anxiety of the surgeon than a distended intestine.

It is also very important that the anæsthetist should be familiar with this class of operation.

Before the commencement of the administration of the anæsthetic a needle is introduced into the loose tissue in each axilla, and normal saline introduced to the extent of about five or six pints. This subcutaneous infusion is continued steadily during the operation.

I find a long skin incision to one side of the middle line more useful than one directly in the median line, as

the double layers of the sheath of the rectus appear to afford a stronger and more resistant junction.

The gastro-intestinal tract is thoroughly explored. After the large bowel and the last six or eight inches of the small intestine have been tied off from their peritoneal attachments, the ileum is grasped transversely by two long artery forceps lying parallel to one another and close together, and the bowel is divided, preferably with the cautery, between these forceps. Fig. 64 illustrates the forceps which are very useful for this purpose and for colectomy generally. The pelvic colon is drawn up and a sufficient length is left to ensure an accurate and secure junction being effected between it and the end of the ileum. If there are many pedunculated masses of fat about the wall of the large bowel, it is advisable to ligature and remove them so as to leave a nice smooth surface before effecting the junction with the small bowel.

It is grasped in a similar manner in two strong forceps and is divided by the cautery between the forceps.

After the surgeon has satisfied himself that the ileum is not twisted on itself, the cut end of the ileum and the cut end of the pelvic colon are placed against each other. The forceps are rotated upon one another in divergent directions so as to bring the adjacent surfaces of ileum and pelvic colon into contact about $\frac{1}{2}$ to $\frac{3}{4}$ of an inch above the cut ends. By means of a continuous suture of fine linen thread perforating the peritoneal and muscular coats these adjacent aspects of the large and small bowel are united securely together.

The controlling forceps are then removed and the burnt edges of both pieces of bowel are separated from one another. Each aperture is held by means of three clip forceps, one grasping the bowel at its mesenteric attachment, one at the point most distant from the mesentery, while the third holds the outer wall of the

bowel at its centre so as to keep the aperture open and facilitate suturing.

Then by means of a buttonhole suture the adjacent margins of small and large intestine are sutured securely together. The advantage of the buttonhole suture is to obviate as far as possible any constriction or narrowing of the lumen of the bowel at the junction, a matter of great importance in many cases. If the lumen of the rectum exceeds that of the ileum, the difference in calibre is readily met by taking in a little larger piece of rectum than ileum at each suture.

The adjacent margins having been secured, the outer margins are brought together in the same manner.

Then by two continuous lines of suture passing through the peritoneal and muscular coats, the outer aspect of the junction is rendered perfectly secure. I employ a second row of sutures on the outer aspect, three rows in all, as the approximation of the outer margins of the edge of the bowel is not so perfectly secure and accurate as is that of the inner.

The interval between the mesentery of the ileum and that of the pelvic colon is closed in very securely by means of a continuous suture of linen thread both along the lower as well as along the upper surface of the approximated cut edges of the mesenteries of the ileum and pelvic colon. Every precaution is taken against leaving any raw surface exposed to which the small intestine may become attached by adhesions. If this closure is not effected the small intestine may prolapse through the interval, and a torsion of the end of the ileum on its long axis result. This condition I have seen frequently in patients who have been submitted to an ileo-colostomy or a colectomy by others. It is responsible for great pain and diarrhœa on the part of the patient, and a natural disappointment with the operation on the part of the surgeon. The mesenteries may

even separate later if not very securely sutured.   This is a matter of vital importance.

At one time in effecting the junction between the ileum and pelvic colon I closed each end and then made a lateral anastomosis between them.   I did this as it was the method in common use for establishing continuity—so - called "side-to-side anastomosis."   I gave this up as both closed ends, and especially the ileal extremity, gradually dilated and after a time formed large blind *cul-de-sacs*.   A considerable accumulation in the ileal diverticulum, bulging into Douglas's pouch, gave the patient the sensation that something was there which should, but could not, be evacuated by straining.   I have seen this bulging develop in the hands of the best operators.

The next method I employed was to close the cut end of the large bowel and to introduce the divided end of the ileum into the side of the closed pelvic colon, forming a so-called "end-to-side anastomosis."   This was a great improvement on the first procedure, but it gradually dawned on me that it did not always form a perfectly satisfactory outlet, and I believe I lost two or three cases from acute obstruction due to the ileal effluent being controlled in some manner.

These cases went on perfectly while the œsophageal tube, which I passed up beyond the junction and retained for five or six days, remained in position, but on its removal symptoms of obstruction appeared, sometimes continuous, sometimes intermittent.   It was always possible to inject material up into the end of the ileum, but the ileal contents would not pass downwards.   This obstruction must arise from some kinking of the bowel at the junction which is difficult to detect or explain.

To avoid this risk I now employ an "end-to-end anastomosis."   I find it much easier to do this than either of the previous methods; the tube can be passed up through

the junction with very much greater facility than in either of the other methods, and no trouble ever arises such as has caused me anxiety in the procedures previously adopted. I believe that this end-to-end method is by far the best, and that this part of the operation is of great importance.

Should a duodenal ulcer be observed, and it be causing no signs of obstruction to the outflow of material from the stomach, it is either left alone or it is inverted by a form of purse-string or other suture.

If it is clearly obstructing the evacuation of the stomach, gastro-enterostomy is performed. Should the obstruction disappear on the healing of the ulcer, the gastro-enterostomy opening will probably close as the duodenal effluent is re-established. I have an intense dislike to putting the stomach out of commission by means of a gastro-enterostomy, unless it is absolutely necessary to do so, as I consider the functions of the stomach of very great importance indeed to the nutrition of the individual. Many surgeons who regard the removal of a useless colon as unjustifiable knock the bottom out of a useful stomach without hesitation. The diagnosis of duodenal ulcer almost always suggests to the physician the necessity of submitting the patient to a gastro-enterostomy and the recognition of an ulcer at the time of the operation is invariably followed by a gastro-enterostomy by most surgeons, while some do still more harm by closing the pylorus. Nature in this instance, wiser than the surgeon, succeeds occasionally in undoing his bad work by closing the gastro-enterostomy aperture and reopening the occluded pylorus.

How many duodenal ulcers have I seen disappear after the administration of paraffin, which has cured the ulcer by freeing the ileal effluent, relieving the obstruction at the duodeno-jejunal junction and restoring the tension in the first part of the duodenum to its normal condition!

Yet the physician delights in transferring these cases to the care of the surgeon.

If there is any considerable mechanical obstruction resulting from an ulcer or cicatrix about the pylorus a gastro-enterostomy is performed. If there is a large ulcer about the lesser curvature I sometimes perform a gastro-enterostomy, dealing with the ulcer by excision or inclusion as seems wisest. At other times I am satisfied to divide the several coats longitudinally along the greater curvature opposite the situation of the ulcer and to suture them together transversely, so preventing the spasmodic contraction of the circular muscular fibre and giving the ulcer a rest. This procedure also increases the depth of the stomach opposite the seat of the ulcer and obviates the development of any so-called " hour-glass contraction." I am under the impression that in a large number of cases of gastro-enterostomy performed for ulcer benefit arises rather from the division of the circular muscular fibres than from the aperture made in the stomach.

The main principle that guides me in my treatment of these cases is to remove the primary cause of the condition by freeing the ileal effluent. In the vast majority of cases the ulcer, which is a result of the distension of the duodenum, will get well without further treatment. If the sequela has reached a stage where it causes mechanical symptoms I deal with it in the manner that seems best.

The chief risk which colectomy presents is that common to all abdominal operations, namely, the formation of inflammatory adhesions between the small bowel and adjacent structures, and these adhesions may so affect the calibre of intestine as to produce symptoms of obstruction, as pain, flatulence, and diarrhœa. The occurrence of hæmorrhage, the infection of the peritoneal cavity from sepsis in the incision in the abdominal wall, the giving way of the

intestinal junction in the very feeble and exhausted, are all possible accidents.

The large majority of cases of colectomy make an uninterrupted recovery, and everyone is delighted with the progressive improvement that results in the patients' condition.

In a small minority as the result of inflammatory adhesions symptoms ensue which may be a source of intense annoyance to the patient and anxiety to the surgeon. In order to avoid these adhesions innumerable means have been adopted.

That which I have found most successful is the introduction into the peritoneal cavity of a considerable quantity of normal saline. When the abdomen is lax and the patient thin and wasted four pints or more can be readily poured in through the incision just before the completion of the deep suture. If the abdominal wall is tense this can be done efficiently through a narrow thick-walled rubber tube left in the abdomen after the wound has been almost completely closed, when pressure can be exerted on the fluid to facilitate its introduction.

I have reason to know that some of this fluid remains in the cavity for more than ten days, while the surface of the peritoneum is soft and shiny, showing no tendency to the formation of adhesions. This is the only means by which I have been able to avoid the formation of adhesions with any certainty.

Before the abdomen is closed an œsophageal tube is passed up the rectum through the junction into the ileum for about eight inches. The use of this tube is particularly important when the calibre of the junction is small, since it eliminates any possible hesitation in the passage of material from the ileum into the pelvic colon. The tube is secured by means of a stitch to the back of the labium or to the margin of the anus in the male. It conveys gas and

fæcal matter into a vessel under the bed for about six days. If any difficulty is experienced in passing the tube a quantity of paraffin is injected through it into the pelvic colon, which it distends and then passes through the anastomosis, facilitating the introduction of the tube into the ileum.   This injection is repeated daily night and morning.   The tube serves to empty all gas and fæcal matter at once, so that any accumulation in the intestine is avoided and all discomfort from flatulence is eliminated.

The patient is rarely sick after the procedure, and is able to take fluid nourishment soon after the operation.

Should complications such as suppuration in the incision or an accumulation of material in the stomach due to spasm of the pylorus arise, the former is met by opening up the wound at the earliest intimation of sepsis, and the latter by the prompt use of the stomach tube.   It is not always easy to detect suppuration in the wound, as it may be deep seated, and the thermometer and pulse may afford no indication of its presence.

The Advantages Derived from a Freeing of the Ileal Effluent.

I need not say that operative interference should not be considered till all other effective means have been tried to meet the disability, when the operation which obtains a maximum of result with a minimum of risk should be resorted to.

Doubtless at no distant time many of the toxic conditions that arise in consequence of stasis may be met with by some means other than operative. If colectomy has done no more good than to point the way to the physician it has more than fulfilled its expectations.

What are the benefits that result from colectomy ?

I instance colectomy, not that it is by any means the

only way by which the ileal effluent can be freed from control, but because it is the most certain way, and I have now under observation a large number of cases in which this operation has been performed for various conditions apparently at first sight having no connection with one another. I can quite sympathise with the observer who considers the subject of chronic intestinal stasis without having had the advantages of carefully observing and studying these patients before and after operation, since the results are indeed startling. As an instance of this mental attitude I would quote a few lines from Professor Adami's most interesting lecture published in the 'British Medical Journal,' January 24th, 1914 :

" To-day I want to consider, not as a clinician, but as a pathologist, how far we may reasonably accompany Sir Arbuthnot and to what extent his doctrine is to be accepted ; for honestly at first sight these seventeen symptoms and nine diseases, indirectly induced, seem to be in a horrible jumble." He then goes on to accuse me of " that most dangerous, if not the last infirmity of noble minds, obsession."

I am not referring to these remarks in any critical spirit, but in a most kindly and sympathetic one, since, till I saw the marvellous consequences of freeing the ileal effluent, I should have adopted exactly the same sceptical attitude and would have required very definite evidence to convince me.

That evidence has now been before the world for a long time, and these patients have been carefully observed by all the ablest and the most distinguished surgeons in the world. They still exist in increasing numbers, and are always at the disposal of any observer who will take the trouble to investigate them.

It is no longer a question of argument, it is a fact which is absolutely clear and unassailable.

The benefit the patient derives from operation in "simple stasis" varies according to the severity and duration of the disease. The patient improves in every particular, she puts on fat, the skin becomes soft, warm, and clean, while the offensive secretion of the axilla and groin disappears. She becomes happy and bright instead of miserable and depressed. The blood pressure becomes normal, the circulation good, and the hands and feet are warm instead of being cold and clammy as they were before the operation. She loses the rheumatic pain in the joints and muscles, and the headache and neuralgia from which these patients suffer so much, and often so intensely. She no longer suffers from breathlessness. She is able to resume her ordinary duties. Her breasts become soft and natural. Her appetite for food is restored, and she can eat anything without pain and discomfort. Her sexual desire returns, and becomes very active. This is particularly the case if she has been married previous to the operation. Whereas before the operation she probably had a dislike or even disgust for intercourse she is now very markedly the reverse.

These facts are all very familiar to those surgeons who have performed colectomy for chronic intestinal stasis, and as their number is now numerous I will not describe them in further detail here.

The conditions which now interest us most are those which appear to develop in people because they are the subjects of chronic auto-intoxication which depreciates their vitality or resisting power to the inroad of organisms or to the action of toxins, which normal healthy tissues appear able to resist.

Much as I dread exposing myself again to Professor Adami's charge of collecting diseases which form "a horrible jumble," I will take my courage in both hands and do so.

I will begin with rheumatoid arthritis.

What can be more startling than the effect of colectomy upon a case of acute rheumatoid arthritis? One sees a patient who has lain on her back in agony for many months, or even years, dreading any movement in her swollen and
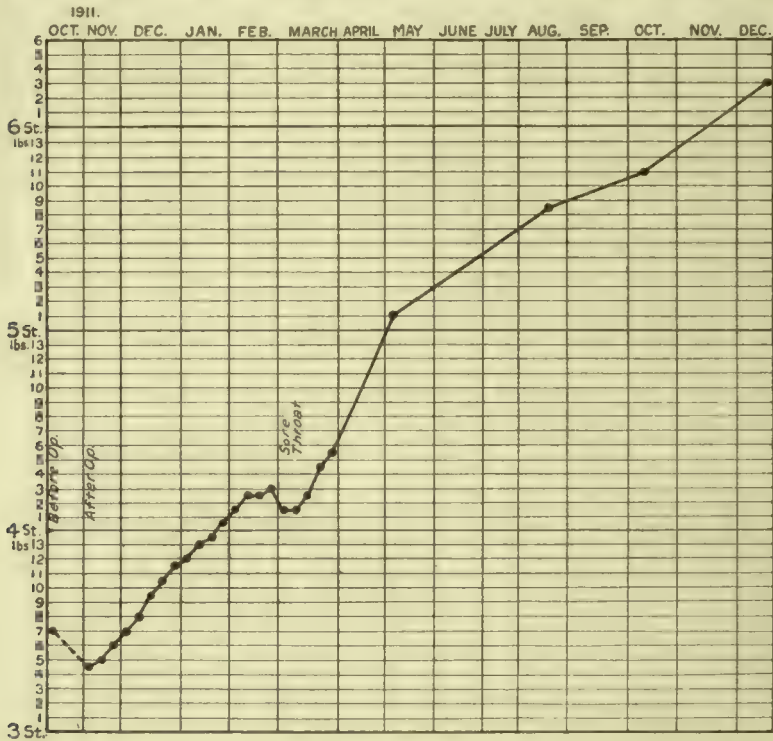
Fig. 65.

painful joints. Within twenty-four hours after the colon has been removed the patient is able to move every joint in which bony ankylosis had not previously existed with great freedom and with absence of pain.

To see these patients rapidly regain freer and freer movement in those diseased joints, to see them progressively restored to health and happiness, and to watch their weight go up by leaps and bounds is a joy to the surgeon.

Fig. 66.

Many of you may remember a child with rapidly progressive rheumatoid arthritis who had been operated on at
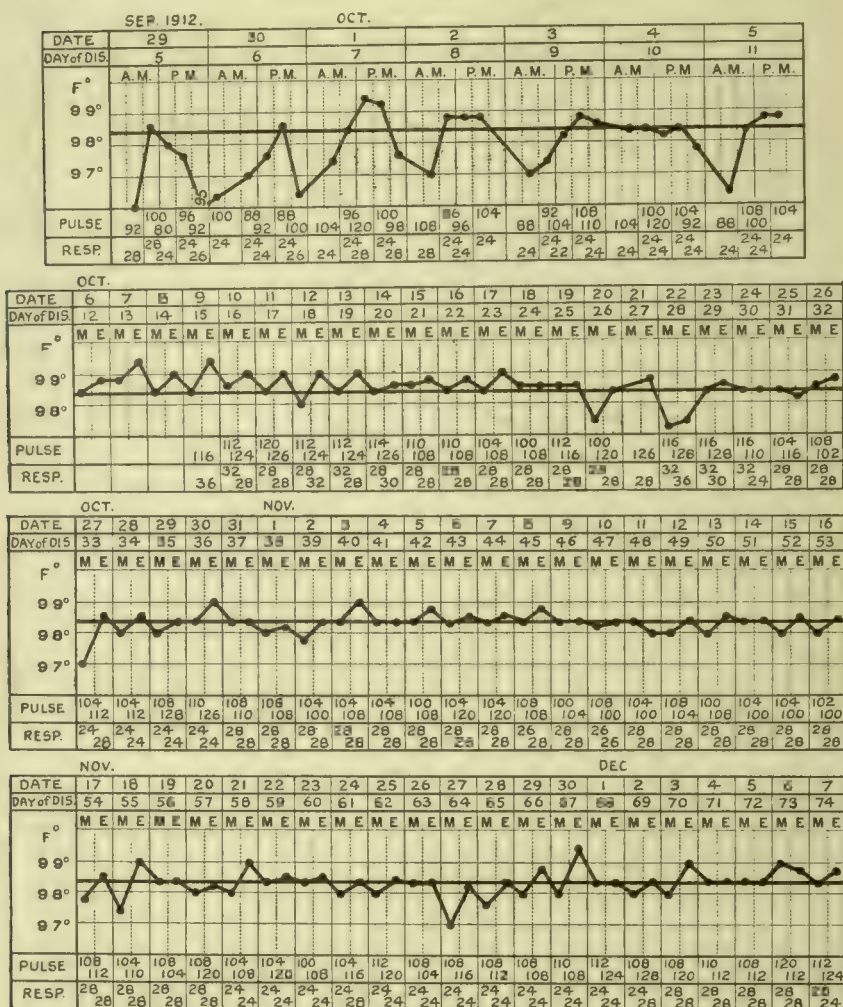
Fig. 67.

the age of $10\frac{1}{2}$ years, and who was shown at the American Congress in London in July, 1914. She had lost every evidence of her disease except certain ankyloses which pre-

ceded the operation, and had doubled her weight in thirteen months. The following is a report of her case (Fig. 65):

A female, æt. 10½ years, a helpless cripple, suffering from rapidly progressive rheumatoid arthritis in spite of careful and constant treatment. She was short-circuited in November, 1911. This chart shows her weight before the operation to be 49 lb. She lost 2½ lb. during the fortnight following the operation, her weight on November 13th being 46½ lb. On October 1st, 1912, thirteen months after the operation, her weight was 87 lb., so that between November 13th, 1911, and December 24th, 1912, her weight had increased by 40½ lb., or in other words, in thirteen months she had nearly doubled her original weight. On consulting Dr. Still's work on ' The Common Disorders and Diseases of Childhood,' he puts the normal increase in weight at this age at 6 lb. in the twelve months. This shows that the improvement in her drainage scheme had produced an increase of more than six times the normal. Besides this abnormal increase in the growth of the child her disease was stopped abruptly, and she is now a vigorous, active, and healthy child.

What cases were more hopeless than these previous to this procedure ?

Take a similar disease, and, fortunately, a much rarer one. I refer to that discovered and described by my distinguished colleague, Dr. Still.

The following details refer to a typical case of Still's disease in a boy, æt. 6½ years, showing glandular and splenic changes—stiffness in the neck with painful and tender joints which showed no bony changes. There was fluid in the joints. He was unable to walk. He had been ill for two years, during which time he was treated at the Evelina Hospital. He was extremely wasted, and appeared to have an adherent pericardium. Dr. Still saw the case and confirmed the diagnosis, and, approved of operative

interference as offering him the only chance of recovery.
The accompanying temperature chart (Figs. 66 and 67) shows
his condition from his admission on August 28th, 1912, till
the date of operation, September 24th, 1912. Several rises
of temperature took place with corresponding changes in the
pulse and respiration. In these attacks the child was very
ill, and his blood gave a pure culture of *Staphylococcus
citreus*. He showed distinct clinical and X-ray evidence of
chronic intestinal stasis. After the operation of short-
circuiting the child had no subsequent rise of temperature.
This fluctuated below normal till October 4th or 5th, 1912,
and then continued uninterruptedly at a normal level. At
the operation the end of the ileum presented a well-marked
ileal kink. The mesentery contained a great number of
large glands. The pelvic colon was very long, a condition
we have observed to be constantly present in tubercular
and rheumatoidal affections in young life. A swab taken
from the contents of the ileum gave a culture of *Staphylo-
coccus citreus*. The general condition of the patient and the
size and mobility of the joints improved rapidly almost
immediately after the operation, and within a few weeks
the child was able to play about the ward, where he
remained till January 8th, 1913. Since that date he has
improved steadily, both as regards his joints and his
general health. This boy was also shown to the American
surgeons at the Congress in July, 1914, in London, and he
delighted them by describing how he saved the reputation
of his school by making a large number of runs. In spite
of this success cases of Still's disease are allowed to progress
to the post-mortem room without being afforded the only
known means by which they can be cured.

Perhaps tubercle is the disease that most commonly
calls for operative treatment. I have now operated on a
considerable number of cases of tubercle, such as tuber-
cular ulcers of the intestine, huge tubercular glands in the

mesentery, tubercular disease of joints, with or without added infection, tubercular disease of the lungs, etc. The operation of colectomy has been successful in all except in advanced disease of the lung. In some of the cases of ulceration of the small intestine I have been satisfied to perform a colectomy, while in others I have removed also the portion of ileum containing the ulcers.

The following case illustrates very well how complicated an apparently simple condition may be, and how readily even the most extensive complications may recover after colectomy.

A man, æt. 22 years, was sent to me in order that I might amputate his hand and wrist.

For six or seven months the right wrist had been very much swollen and very painful. During this time it had been treated by absolute rest, diet, and drugs without its steady increase in size, pain, and uselessness being at all influenced by treatment.

Except for his wrist he considered himself perfectly well. I sent him to Dr. Jordan, who showed the destructive changes in the wrist (Fig. 68), and also that the delay in his drainage scheme was very marked. The condition of his mediastinum is seen in Fig. 69.

Fig. 68 shows the effects of tuberculous disease of the right wrist in a man of 22, the left wrist being normal. The bones are much rarefied in texture, and there is extensive pulpy thickening around the wrist.

Fig. 69 shows a mass of enlarged glands in the chest above the root of the right lung. Presumably these glands were tuberculous. The patient exhibited marked evidence (both radiographic and clinical) of chronic intestinal stasis, and this was confirmed at the operation.

At no time had the patient ever complained of pain or discomfort in his abdomen, yet on examination not only was the end of the ileum found to be very tender, but many

of the lower coils were very distinctly sore on pressure.
Some suspicious lumps could be felt in the mesentery of
the ileum.   Colectomy was performed.

Very extensive ulceration of the ileum existed, and the

Fig. 68.

floor of the lowest ulcer, which was in the immediate
vicinity of the cæcum, was almost perforated.   There were
many large tubercular glands in the mesentery.

The ileum was divided about eight inches from its
termination, two only of the ulcers being removed.   He
made an uninterrupted recovery, and left the hospital
three weeks after the operation.

He was shown at the American Congress in July, 1914,

when the swelling of the wrist had almost entirely disappeared.

There are one or two points of interest in relation to abdominal tubercle which would appear to show that the observations of the physiologists as made upon animals do

Fig. 69.

not give us a very correct idea of the possibilities in the human subject. In evidence of this the following report throws some light. I removed the large intestine of a girl affected with extreme stasis. This portion of the bowel was much ulcerated, and it perforated at several points while it was being removed. She progressed perfectly for nearly four weeks, when a fistulous opening appeared in the middle line through which a portion and then all the

contents of the bowel escaped. She was too feeble to make any further operation at the time advisable, so we fed her with very nutritious food and watched her. She steadily but slowly increased in weight during the two years following on the operation. During this time she led an active life, and met the discomfort of the fistulous opening by clever little dodges which she herself devised. We gave her bismuth and examined her tract, and found that not more than 18 in. of jejunum were functioning. At the end of this time she wished the opening closed. We therefore opened the abdomen, confirmed by measurement the length of small intestine which had been sufficient to meet her daily requirements of energy and also to add to her weight, and we established continuity of her small intestine.

Having learnt what a limited portion of the small intestine is requisite to carry on life, I have not hesitated to remove the large bowel in cases in which the glands of the small intestine were matted up, forming a large caseous mass, and I have had no reason to regret doing so. In tubercle of the abdomen more than elsewhere does rapid disappearance of the disease follow the removal of the large bowel by colectomy.

Many cases of stasis suffer severely from infection of the skin.

One had an extensive pustular eruption which had resisted all forms of treatment, but which disappeared after colectomy.

Perhaps one of the most distressing skin conditions for which colectomy was performed was a chronic pruritus of the labia and anal region, which made the patient's life unbearable, and prevented her going about among her friends. The patient showed herself nine weeks after the operation, when she had gained greatly in weight, her old pallid stained face was replaced by rosy healthy skin, and

she had quite lost her severe pain, sickness, and flatulence, and was able to eat anything. The skin irritation disappeared within a few days of the operation.

In uncomplicated stasis the thyroid wastes till it may be imperceptible to the finger. It gradually but slowly increases in size after colectomy. I fancy that the wasting of the thyroid plays an important part in the development of the symptoms which the sufferer from chronic intestinal stasis exhibits.

What the organisms or toxins are that determine the development of general hypertrophy of this gland, of exophthalmic goitre, or of adenomatous changes in this organ I do not pretend to explain, but this I know, that in every case suffering from these conditions in which we have performed colectomy the disease has disappeared completely. The recovery in the case of colectomy in exophthalmic goitre is a very different thing from the amelioration of symptoms which frequently follows a partial resection of the thyroid gland, which procedure deals with one effect but imperfectly, leaving the primary cause of the disease untouched.

I have already called attention to the fact that the earlier colectomy is performed in the course of the disease the better is the result. Indeed, it would seem quite possible that a stage could be reached in which no benefit whatever might result to the patient from operative interference.

Short of this extreme there are certain very severe cases in which, owing to the poor surroundings of the patient or to inability to take sufficient care for a long enough period after operation or to very great strain, symptoms may return after a varying interval of time, although the ileal effluent appears to be quite free.

I believe that such recurrences can be avoided by prolonging the convalescence and by avoiding any severe strain or exposure.

These cases would seem to show that although complete recovery may appear for a time to follow the operation, the tissues that have been poisoned for a long period have not the same resisting power as normal tissues. This makes the problem of stasis a more complicated and more interesting one than would appear from the study of the results of the average colectomy, and I think we may learn much from a careful analysis of these cases.

The two following patients serve to illustrate this point. They are particularly interesting as in both the nervous system is affected, though in apparently different areas.

I have already described the remarkable and abrupt cessation of pains in the head and of intense neuralgia which follows on colectomy. A woman had suffered for nine years from very severe attacks of epileptiform tic in the right fifth nerve. Apart from the violent attacks the whole side of the face was always very painful and sensitive to touch. An ileo-colostomy was performed. She had no epileptiform attack after the operation, but for eight days the pain in the right side of the face remained, but it gradually diminished in severity. It disappeared completely on the ninth day. She was also relieved of all her other symptoms of stasis, which was very marked.

She went on for about eight months absolutely free from pain. Then after a long and boisterous sea voyage she had to take a train journey of three days' duration under most trying conditions. She arrived at her destination thoroughly exhausted and worn out, and her digestion was very much upset. Her pain and attacks reappeared and continued as before the operation. She returned to England from South Africa in an emaciated condition and with much digestive disturbance. Her large intestine was removed without any immediate benefit. She was kept quiet in bed and carefully fed. It seemed that the reason of her continued pain was that while exhausted from want of food

she was affected by auto-intoxication subsequent on an infection of her stomach and small intestines. It was impossible to relieve this as she would not move her tongue, which was coated with a thick, offensive, epithelial covering, and she would only take a very small quantity of food.

To meet this condition I removed much of the right lingual gustatory nerve, and enabled her to eat and relieved the infection of her intestinal tract. She is now improving rapidly as regards her intestinal condition, while she is freed from her pain.

With the exception of this case the headache and neuralgia have disappeared after colectomy.

The second case was the most advanced condition of Raynaud's disease on which I have operated. How far Raynaud's disease should come under this group of secondary infections, or under that brought about by simple auto-intoxication I do not know, since one sees every gradation between the cold clammy hand and the most advanced type of Raynaud's disease. The man was æt. 24 years. He had suffered from this disease for nine years. It had totally incapacitated him from following any occupation, since not only had he no feeling in his hands, but they were very swollen and fixed in a position of flexion so that he was unable to grasp or hold anything. The tips of three of the fingers of the left hand had been lost from dry gangrene. He was such a typical and instructive case that he had spent twelve months in Guy's Hospital, under the care of the several physicians, in order that the students should become familiar with the symptoms of this disease.

I mention these facts to show that this particular case had been very carefully studied. He had had almost continuous medical treatment for the last two years, including Faradism and light baths. He had spent a year in an infirmary, as he was unable to earn a living.

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He was very thin, almost emaciated.

He was very markedly static both in appearance and as shown by a bismuth meal and X-rays.

Dr. Mutch showed that his blood pressure was 115 m.; hæmoglobin, 78 per cent.; colour index, ·8; leucocyte count, 13,400 with positive lymphocytosis; his urine contained a little indican and much hydroxyphenyl acetic acid. Colectomy was performed on October 8th, 1914, when the X-ray report was verified in every detail.

Dr. Mutch found *Streptococcus brevis* in the duodenal contents. The contents of the terminal ileum were alkaline, and from them *Bacillus coli*, *Streptococcus brevis*, and a Gram-positive streptobacillus were obtained.

The combined flora acting on peptone gave small quantities of pressor bases.

The hands recovered at once, and seven weeks after operation were in perfect condition. Palms and dorsums reacted in a normal manner to cold. Ice-cold water did not induce an attack of blue or white fingers.

He went to a convalescent home, and then resumed his old occupation as a printer, under unfavourable conditions.

On December 14th the attacks returned.

He will be readmitted in the hope that he may recover if placed in favourable conditions.

It seems reasonable to suppose that, if after the operation his convalescence had been more prolonged, and if his lot had been placed in more favourable circumstances, he would have remained permanently free from attacks.

As regards the secondary infections of the colon constituting the various types of colitis, when it has been called for, I have removed the large bowel with complete success except in a case in which the patient was practically dying when operated on.

The only difficulty which I have experienced in certain cases of ulcerative colitis was in uniting the end of the ileum

to a colon whose wall was enormously hypertrophied, whose lumen was much reduced, and whose mucous membrane was deeply ulcerated. The mechanical difficulties in such a condition may be very great but are not insuperable.

On the other hand, in mucous colitis an extreme thinning of the walls of the intestine may add to the difficulty of the operation.

I might add very materially to the diseases which depend on an infection of tissues whose resisting power has been lowered by chronic intestinal stasis and which have been cured by freeing the ileal effluent, but I feel I have brought forward enough evidence to make my meaning clear, and I trust also to convince my readers that chronic intestinal stasis is a subject which at least deserves their careful consideration.

I believe that many of these surgical procedures may be obviated by medical treatment when the physician will have learnt something more about the bacteriology and chemistry of the contents of the intestine, and of the influence which they and their products exert upon the several tissues of the body, than he knows at the present time.

The following remarks by Dr. Jordan, Dr. Mutch, and Dr. James Mackenzie will serve to render the subject more complete from radiological, bacterial, chemical, and clinical standpoints.

CHAPTER II.

THE INVESTIGATION OF CHRONIC INTESTINAL STASIS BY THE X-RAYS.

BY

ALFRED C. JORDAN, M.D., M.R.C.P.

METHOD.

THE method which has afforded me the most trustworthy information in demonstrating the existence of chronic intestinal stasis is the administration of an emulsion of four ounces of carbonate of bismuth and an ounce and a half of sugar-of-milk in a tumbler of water about an hour after an ordinary breakfast. No aperient or enema should be used for two days previous to, or during, the investigation. All meals should be taken as usual.

POSTURE.

The patient is upright while taking the bismuth; then he is examined on the couch.

THE NORMAL SUBJECT.

In a normal case the bismuth passes rapidly through the œsophagus into the *stomach*, when regular peristaltic waves are seen, and small portions of the bismuth may enter the duodenum. The result of the introduction of the bismuth is that in the erect posture the greater curvature falls about one inch below the level of the umbilicus.

Examining the patient on the couch, regular peristaltic waves move along both curvatures to the pylorus, and bismuth enters the *duodenum*, and passes through the four parts of the duodenum as the result of a normal duodenal peristaltic wave, and enters the jejunum. The duodeno-jejunal junction is rounded, offering no obstruction to the course of the bismuth. The second part of the duodenum measures $2\frac{3}{4}$ in. to $3\frac{1}{4}$ in. It is usually impossible to obtain a skiagram of the normal duodenum, for with an ordinary "time" exposure the bismuth may be seen to leave the duodenum after a few seconds. If an instantaneous method be used but a portion of the (normal) duodenum is shown, for only a part of it contains bismuth at any particular moment.

By the end of two or three hours the whole of the bismuth has left the stomach, being seen widely scattered through the small intestines, but especially in the lower coils of the ileum above the pelvic brim.

After three and a half to four hours bismuth has begun to enter the cæcum.

After five or six hours there is no longer any bismuth in the small intestine, the whole of it occupying the cæcum and ascending colon.

At the end of eight to twelve hours some bismuth has reached the splenic flexure.

After twenty-four hours the bismuth is distributed through all parts of the large intestines, some having reached the rectum or been evacuated.

At the end of forty-eight hours the whole of the bismuth has been evacuated.

Chronic Intestinal Stasis.

In patients suffering from chronic intestinal stasis definite changes are seen at the first and at each subsequent examination.

In the vertical posture the thoracic viscera are inspected. Frequently we find indications of arterial disease. They consist at first of an *elongation of the aortic arch*, as shown by undue obliquity of the long axis of the heart (Fig. 77). At a later stage, when there is actual *dilatation of the arch*, its shadow appears prominently on both sides of the vertebral column, and the long axis of the heart is nearly horizontal. In the right anterior oblique position the actual diameter of the arch can be measured. In this position

Fig. 70.—Œsophagus, greatly dilated, taken vertically in the right anterior oblique view in a typical case of cardiospasm in a woman aged 39. A. Aortic arch; the arrows indicate the spasmodic constriction of the lower end of the œsophagus.

the *posterior mediastinum* is studied. Any enlarged glands in this region are easily seen.

While the patient swallows the bismuth emulsion its course through the *œsophagus* is observed. Occasionally we notice spasm at the cardiac orifice. In cases of *cardiospasm* the bismuth may be delayed in this situation for a period of time varying from a few minutes to several days, and the œsophagus is dilated, sometimes to an extreme degree. In the case represented in Fig. 70 most of the bismuth was still in the œsophagus after six days.

Dropping of the greater curvature of the stomach is found

in a large percentage of "stasis" cases examined in the upright posture, and this may be so marked a feature that the level of the greater curvature may correspond to the pelvic brim.

The *duodenum* is large in stasis cases and remains full of bismuth; its *second part* may measure five or even six inches instead of three inches, while its diameter is increased proportionately (Figs. 78 and 79, p. 112). The *first part* of the duodenum shows the greatest dilatation. Duodenal peristalsis is abnormally powerful, and in severe stasis strong, deep waves pass along the four parts of the duodenum, driving its contents before them, but these, instead of entering the jejunum, return time after time to the second or even to the first part of the duodenum. Eventually a portion of the bismuth is forced through the duodeno-jejunal junction into the first loop of the jejunum. This junction forms an acute angle, the first piece of the jejunum being placed vertically. This struggle of the duodenum to expel its contents may continue for many hours without intermission.

The phenomenon of the distended "writhing" duodenum is best seen in patients who are leading an ordinary life in spite of their poor health. If kept in bed for any time previous to the investigation this exaggerated movement of the duodenum is not shown so clearly, although its dilatation is usually quite evident.

Persistent pyloric spasm is a constant phenomenon in chronic intestinal stasis, and many observers have failed to demonstrate the true state of the duodenum because they have not recognised the necessity for arranging their observations in such a way as to overcome, as far as possible, the spasm at the pylorus for the time being. The spasm is greatest just after a meal and relaxes gradually during the next hour, allowing some of the gastric contents to escape. This is the best time to give the bismuth emulsion.

It should contain enough carbonate of bismuth to neutralise the free acid in the stomach, for the hyperacidity usually present in stasis increases the spasm at the pylorus.

Delay in the stomach is always present in stasis, except in patients confined to bed. We frequently find some bismuth still in the stomach after twelve hours or more.

Delay in the lower coils of the ileum is always present in stasis. The amount of delay is not exactly proportional to the degree of the stasis, for the rate at which bismuth enters the lower coils of the ileum is regulated by the rate at which it leaves the stomach and duodenum, and this is often very slow.

Six or seven hours is usually the most favourable time after the bismuth meal for showing the details of the ileo-cæcal region in stasis cases.

The *cæcum* should be examined in the upright posture as well as on the couch, and the degree of its mobility determined.

The *terminal coil of the ileum* is usually hypertrophied, and may be felt as a thick cord, tender on pressure. The peristalsis of this coil is often unduly powerful, and the last half inch is constricted by spasm, so that only a thin thread of bismuth enters the cæcum. Fixed points along the terminal coil of the ileum must be made out accurately. They constitute " *Lane's Ileal Kink.*" A fixed point is recognised (*a*) by its immobility during inspiration if near the cæcum; (*b*) by its fixation when pressed upon with the fingers, while the rest of the coil moves freely ; (*c*) by an examination in the upright posture the position and the effect of an ileal kink can be shown to perfection in some cases. Fig. 71 shows how an ileal kink produces obstruction in the erect posture, while Fig. 72 demonstrates the disappearance of the obstruction when the supine position is assumed. The very earliest commencement of an ileal kink can be demonstrated. In the upright posture the

cæcum falls, and even on the couch the observer must often raise the cæcum before he can demonstrate the terminal coil of the ileum. The tenderness of this coil is usually greatest at the ileo-cæcal entrance and at the seat of a kink.

The *appendix* is very often found to contain bismuth. Palpation elicits tenderness, fixation, and abnormalities of form. Occasionally we can show that the appendix and

FIG. 71.   FIG. 72.

the terminal coil of the ileum are kinked by the same band (Fig. 49, p. 39). In other cases the appendix is observed to run up behind the end of the ileum, and to be fixed in such a way that it obstructs the outflow from the ileum to the cæcum in the upright posture. This I have indicated diagrammatically in Fig. 73. If, in a case of ileal control, a definite thickening, resembling a short, vertical cord is felt at the ileo-cæcal entrance, we may be sure that it is appendical in origin, even if bismuth cannot enter the appendix because its outlet is obstructed from the tension exerted on it by the loaded cæcum and ileum. This is

well illustrated by Fig. 74, in which, while a controlling
appendix could not be demonstrated with bismuth, its
presence was suspected and was confirmed by operation.
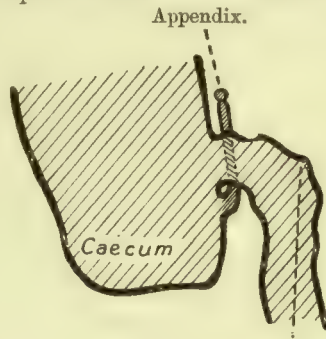
Congested, irregular, thick-walled ileum.
Fig. 73.

The times of the subsequent examinations are usually
about as follows : Twenty-four, thirty-three, forty-eight,

Fig. 74.

Fig. 75.

seventy-two and ninety-six hours.   The last is double the
normal time for the complete evacuation of the large
intestine.   If bismuth is still present after this time no
better evidence of stasis in the large bowel can be offered.

The *hepatic flexure*, or the first part of the transverse colon is often the seat of bands, fixing the bowel from above (see Fig. 75). This flexure moves down with the liver on inspiration, but cannot, as in a normal case, be held down, away from the liver, during expiration. The hepatic flexure often drops in stasis.

The *splenic flexure* rarely drops, even though the transverse colon occupies the pelvis. The splenic flexure, instead of forming an easy curve, may be acutely bent, causing great obstruction. This is shown in the right lateral posture.

The *iliac colon* may take a short course through the left iliac fossa. In stasis it is often thick-walled and tender. Frequently it is fixed in this situation, forming Lane's "last kink." The iliac colon may be firmly secured to the left iliac fossa, and its congested walls may yield, giving rise to the condition of *diverticulitis* (Fig. 35, p. 28).

The *pelvic colon* may be greatly elongated, rising from the left pelvic brim to a level well above that of the umbilicus, and then turning inward and downward to the top of the rectum (Fig. 32, p. 25).

This is frequently observed in the case of tuberculous children. A good-sized motion may occur daily without emptying more than a small portion of the elongated pelvic colon or rectum. Thus the passage of a good-sized motion daily is compatible with the presence of extreme stasis.

This loop, by a torsion on its axis, may become more or less obstructed, an acute or chronic *volvulus* resulting, the latter being readily demonstrated with X-rays.

In case of obstruction preventing the progress of the bismuth beyond the point involved, an enema of barium sulphate, kaolin and warm water gives much additional information regarding the bowel beyond the obstruction.

The work of Sir Arbuthnot Lane has been of inestimable service in the science of medicine in showing that

there is a common origin to most of the diseases of the
alimentary tract, and to many general diseases also.
Hitherto we have been content to diagnose a duodenal
ulcer, a gastric ulcer, gall-stones, chronic appendicitis,
pancreatitis, mastitis, etc., regarding each as an indepen-
dent disease to be treated as such. Now we have learned
that these, and many other conditions, are merely some of
the end results of chronic intestinal stasis, and the only
satisfactory line of treatment is that directed to the cure
of the stasis. The end result does not call for individual
treatment unless it has been allowed to progress to a stage
at which permanent organic injury has occurred. As, for
instance, if a gastric or duodenal ulcer has cicatrised so as
to produce obstruction, or if chronic mastitis or pancrea-
titis has gone on to the appearance of cancer (Fig. 63,
p. 64).

The *rôle* of the radiologist, therefore, is two-fold. He
must show the individual lesions of particular organs, and
he must supply a *detailed* description, fully illustrated, of
the *entire* gastro-intestinal tract, showing the presence
of chronic intestinal stasis—and its degree.

Gastric Ulcer.

Chronic *gastric ulcers* occur usually in one of two
places : at the pylorus or about the middle of the lesser
curvature. At the pylorus a chronic ulcer gives rise to
pyloric stenosis. If the ulcer has existed for long the
stomach will be *dilated*, and this is readily recognised when
the patient is upright, for the bismuth falls at once to the
great curvature, which is lower than normal, and the
bismuth lies here in a shallow pool. Gastric peristalsis is
abnormally powerful, unless dilatation is so great as
to have led to atony of the stomach. On the couch
no bismuth enters the duodenum, the whole of it being

returned to the body of the stomach as each wave passes off. The *pylorus* may be distorted. Occasionally a group of strong *reversed peristaltic waves* may be seen to start at the pylorus, and pass back along both curvatures toward the fundus. This event, when seen, may be taken as positive evidence of the existence of an obstructive lesion at the pylorus.

It is necessary to draw special attention to a fact

FIG. 76.

regarding pyloric stenosis, viz. that a chronic ulcer causes permanent spasm, and gives all the signs, clinical as well as radiological, of stenosis. The spasm may be so persistent that it never relaxes except under a general anæsthetic.

A *chronic ulcer of the lesser curvature* produces a most striking radiographic picture, which, when typical, is absolutely characteristic. In the upright posture the bismuth remains in the cardiac portion of the stomach, which is pouched. From a point on the inner side of the pouch (*i. e.* above the lowest level) a thin stream of bismuth escapes, and drops down to the great curvature of the stomach, which is always lower than normal (Fig. 41,

p. 34).   A small collection of bismuth often remains in a
small pouch on the inner side of the cardiac portion of the
stomach.   This small pouch may contain air in its upper
part, separated from the bismuth by a horizontal line.

Examined on the couch the picture is perfectly typical
(see Fig. 76).   The pyloric portion P of the stomach is
separated from the cardiac part C by an hour-glass con-
striction in the form of a narrow, curved passage, both
sides of which protrude to the right.   Of the two sides, that
on the right is the depressed base of the ulcer, adherent to
a neighbouring organ (the tail of the pancreas or the lower
surface of the liver).   The raised margin of the ulcer is
well shown.   The opposite side of the narrow passage is
the wall of the great curvature, drawn in over the ulcer by
spasmodic contraction of the circular fibres of the stomach.
This hour-glass constriction, though spasmodic, is per-
manent, except during general anæsthesia.   The pyloric
portion of the stomach is large, and has a night-cap-like
projection upward from the great curvature at the seat of
the ulcer.   Pyloric spasm is always present, and may be
so severe and persistent as to resemble organic stenosis,
and to cause the retention of bismuth in the pyloric
portion of the stomach for days.   The duodenum, a, b, c,
is not always easily shown on this account, but if a large
dose of carbonate of bismuth be used there will often be a
relaxation of the pyloric spasm sufficient to allow bismuth
to enter the duodenum.   The typical dilated, " writing "
duodenum of chronic intestinal stasis is then found.

There may be two gastric ulcers : one at the pylorus,
the other on the lesser curvature.

A *chronic duodenal ulcer* just beyond the pylorus
resembles a pyloric gastric ulcer, but if the seat of the
duodenal ulcer is further from the stomach, *e. g.* at the
highest part of the duodenum, or on the posterior or
the right wall of the first part, the effect is different.   The

whole duodenum, in any case, shows the dilatation and the other characters seen in stasis. At the seat of the ulcer there is a slight local depression or irregularity of outline, best shown in the prone posture, but often also in the supine. An ulcer in the more distal portions of the first part of the duodenum may produce a different result, viz. a spasmodic constriction beneath the dilated first part.
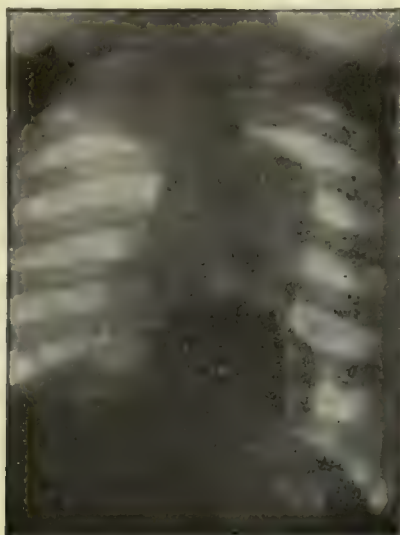
Fig. 77.

Bismuth may lodge above the ulcer for many hours, and a definite slight sacculation or pouching above the constriction may be present, making this condition comparable with the cardiac pouch above a chronic ulcer of the lesser curvature.

An old chronic ulcer in the duodenum may show a round, depressed base with a raised margin, as in the case of ulcer of the lesser curvature of the stomach (Fig. 57, p. 48).

In all these cases of gastric and duodenal ulcer the

course of the bismuth should be followed through the whole of the intestinal tract. In every case the investigation will demonstrate the presence of a high degree of chronic intestinal stasis.

Cancer of the stomach can be shown, in many cases, to have originated in a chronic gastric ulcer. At an early stage the appearances correspond, in every detail, with

FIG. 78.   FIG. 79.

FIGS. 78 AND 79.—Duodenum of a woman, aged 33, taken on the couch after a bismuth meal, showing two phases of its powerful "writhing" contractions. Six and a half hours later nearly all the bismuth was still in the stomach, and the distended duodenum was again shown fighting against the duodeno-jejunal kink. The duodenum was relieved completely by the operation of "short-circuiting" the ileum into the rectum, and six months later the duodenum was found to behave normally with bismuth, and the whole of the bismuth had left the stomach after six hours. *a, b, c, d.* The four parts of the duodenum. *Py.* Pylorus. *U.* Umbilicus. *Cr.* Crest of ileum.

those of gastric ulcer, with merely the slightest differences due to the malignant involvement. When the lesser curvature is the seat of a cancer we find the large pyloric portion, the pyloric spasm, and the distended duodenum just as in simple ulcer (Fig. 58, p. 48).

Cancers in the head of the pancreas, the cæcum,

the hepatic and splenic flexures, the iliac colon, pelvic colon and rectum give rise to irregularities of outline in their early stages, and to obstruction when they are more advanced. In every case (before there is organic obstruction) we find evidence of marked stasis.

The above brief account demonstrates clearly the great diversity of lesions that are directly due to chronic intestinal stasis.

CHAPTER III

DR. NATHAN MUTCH

ON

THE BACTERIO-CHEMISTRY OF THE SMALL INTESTINE

CULTIVATION of ileal chyme obtained during life from the subjects of constipation almost invariably reveals the presence of numerous micro-organisms. That comparable numbers occur in health has been conclusively disproved, and direct evidence of the normal presence of even a few bacteria is still lacking. It must not be supposed that the ileal flora often rivals that of the cæcum in richness. The living bacteria present in one cubic centimetre of cæcal contents are many thousandfold more numerous than those in one cubic centimetre of ileal chyme obtained one centimetre higher in the intestinal tube. The organisms most commonly found are the *Bacillus coli* and its mutants. In association with these bacilli, short-chained, Gram-positive streptococci often live, and not infrequently yeasts and the *Bacillus acidophilus* of Moro. When the clinical picture of intestinal stasis is masked by other symptoms, secondary alimentary infections with less usual organisms are sometimes found; for example:

(1) *Staphylococcus citreus* in Still's disease.

(2) *Bacillus aminophilus* in arterial hypotension.(1)

The severity of the ileal infection with coliform organisms is directly proportional to the degree of ileal delay, and does not seem to be influenced materially by any other factor.(2) The hydrochloric acid of the gastric secretion may be deficient or in excess without affecting the number of coliform bacilli in the ileum. Neither the presence of streptococci nor of *Bacillus coli mutants* bears any direct relationship to the development of evolutionary extra-peritoneal bands; in fact coliform organisms are most numerous and streptococci most frequently present when an ileal kink is but poorly formed or entirely absent.

The bacteria of the duodenum are rarely so numerous as those of the ileum, and coliform organisms are not often found. In this locality also the intensity of the infection is proportional to the delay as measured by the degree of duodenal dilatation. The isolation of other organisms is greatly facilitated by the absence of coliform bacteria, and the flora of this part may strike the key-note of an unusual alimentary infection. For example, it has yielded a free growth of *Streptococcus pyogenes longus* which could only be obtained from the ileal chyme by special methods, whilst all efforts to secure cultures of the coccus from the cæcum failed, although it appeared in considerable numbers in direct smears made from cæcal contents.

Intestinal bacteria give rise to symptoms of disease by generation of poisonous decomposition products from chyme and by infection through the intestinal mucosa, with the discharge of bacterial toxins into the circulation. The upper portions of the intestinal tube are laden with food products, useful alike for human and bacterial life, and the presence of many organisms in these parts results not only in much waste but in the formation of highly poisonous modifications of our food materials, such as amines and ptomaines. On the other hand, although the colon can absorb sugar and proteolytic products as well as water and

salts (3), it is normally given small opportunity of exercising
this function, since mere traces of diffusible carbohydrate
and amino acids pass the ileo-cæcal valve. The loss of
these remnants is inconsiderable, but it is most important
that toxic modifications should not be evolved. A luxuriant
colonic flora is therefore provided to ensure their rapid
destruction into relatively innocuous bodies, such as phenol,
ammonia, water, carbon dioxide, and hydrogen, whilst being
stored up for daily evacuation. To put the matter briefly,
the upper alimentary tract is specialised for aseptic absorp-
tion of food, and the colon for bacterial destruction of
residues. The invasion of the ileum in constipation by a
restricted number of bacteria, not too versatile in their
chemical potentialities, gives rise to various food decom-
positions, and the nature of the toxins elaborated depends
upon the particular combination of organisms present. It
has been possible to trace the disintegration of three amino
acids, tyrosin, histidin, and tryptophane, each of which may
be considered in turn.

Tyrosin is converted by certain strains of intestinal
organisms into the pressor body hydroxyphenylethylamine,
which, after absorption, is converted by the liver into
p-hydroxyphenylacetic acid and eliminated as such in the
urine. This acid is not excreted in health, but can be
isolated in a pure state from the urine of patients suffering
from intestinal stasis (4). It is readily detected by applying
Millon's test to an etherial extract of acidulated urine.
When it is present the amount excreted is proportional to
the intensity of the coliform infection of the ileum and to
the degree of ileal stasis. Gastric hypoacidity also favours
its production. It disappears from the urine after ileo-
colostomy.

OH   Action of bacteria ⟶   OH   Action of liver ⟶   OH

$CH_2.CHNH_2.COOH$ $CH_2.CH_2NH_2$ $CH_2.COOH$

Tyrosin (useful).   Hydroxyphenylethylamine (toxic).   p-Hydroxyphenylacetic acid (useless and innocuous).
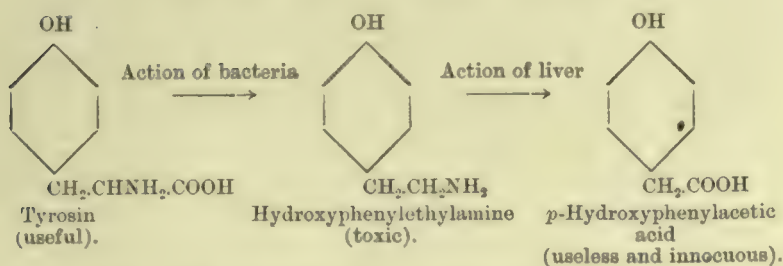
Histidin is converted by *Bacillus aminophilus* into β-Iminazolylethylamine, a powerful depressor body, which is not destroyed by the liver, and therefore readily affects the general circulation. *Bacillus aminophilus* is found in the static ileums of patients only who suffer from subnormal blood-pressure. Out of twelve consecutive constipated patients, four harboured this organism in their ileums and their brachial blood-pressures were 108, 106, 102 and 97 mm. Hg. respectively. The remaining eight were free from this infection, and their blood-pressures were 140, 132, 128, 126, 125, 122, 120 and 114 mm. Hg. respectively (1).

$CH = C.CH_2.CHNH_2.COOH$ $CH = C.CH_2.CH_2NH_2$

N   NH   N   NH

CH   CH

Histidin (useful).   β-Iminazolylethylamine (toxic).
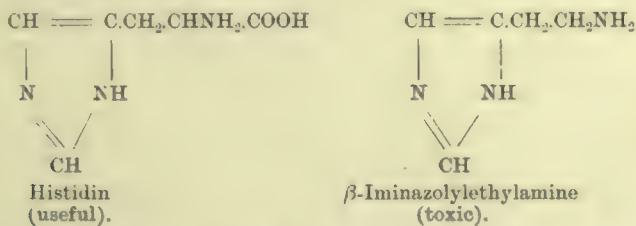
Tryptophane, under the influence of certain coliform organisms, is converted into the pressor base, indolethylamine, which is changed by the liver into indolacetic acid, and excreted as such in the urine. This acid is often present in the urine of constipated subjects, and is readily detected by the rose-coloured pigment to which it gives rise on the addition of hydrochloric acid and a trace of sodium nitrite. Another tryptophane derivative, indoxyl, is even more frequently present in the urine. When these

substances are formed the amounts excreted vary directly as the degree of ileal stasis and as the severity of the coli-form infection in the ileum. Their formation is also favoured by gastric hypoacidity. Ileo-colostomy frees the urine from these bodies as completely as from the tyrosin products.

| Tryptophane (useful). | Indolethylamine (toxic). | Indolacetic acid (useless and innocuous). |
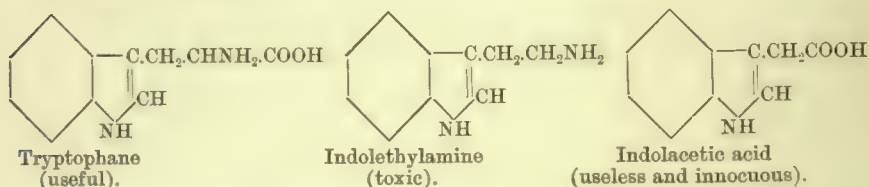
The syndrome occurring with chronic *Staphylococcus citreus* septicæmia of alimentary origin affords one of the best instances of disease arising from infection through the intestinal mucosa. The chronic joint, spleen, and lymphatic changes which are thus occasioned are usually classified as Still's disease, and the description of such a case in the earlier part of this book fully correlates the bacteriology with the clinical signs of this disorder.

Diagnosis.—1. Infection of the small intestine with coliform organisms can be inferred when indoxyl, indol-acetic acid, or hydroxyphenylacetic acid appears in the urine of a constipated patient whose gastric secretion is not deficient in hydrochloric acid.

2. *Bacillus aminophilus* infection of the ileum of a sufferer from intestinal stasis is indicated by a subnormal blood-pressure.

3. Alimentary infection with *Staphylococcus citreus* is revealed by the presence of the symptom complex known as Still's disease.

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CHAPTER IV.

X-DISEASE: AN EXTRACT FROM 'DISEASES OF THE HEART,'*

BY

JAMES MACKENZIE.

Dr. James Mackenzie, whose original work has produced such a remarkable change in the medicine of the present day, has kindly permitted me to quote from his book on 'Diseases of the Heart' the following pages, which illustrate so thoroughly his very acute powers of observation. They were written eight or nine years ago, at which time he had not yet come to the conclusion that he now has, that the conditions he called X-disease and chronic intestinal stasis were identical.

The Circulatory Symptoms in the X-Disease.

(I employ the term " X-disease " for the reason that I do not know the nature of this complaint. Many physicians call members of this class " neurasthenics," and are content to leave the matter there. This is simply to give a complaint a name, which is so satisfying that the fact is often lost sight of that the name sheds no light on the complaint and is nothing but a cloak for ignorance. If the term " X-disease " be employed, it will be a glaring acknowledgment of our ignorance, and will lead to constant endeavour to clear up the mystery surrounding these cases.)

* Third Edition, p. 100 *et seq.*

There is another class of cases of somewhat indefinite character that needs to be recognised in order to appreciate other forms of heart trouble. The class I allude to will be recognised by every practitioner, as they form a considerable portion of the community. The individual is spare and thin; the face is often drawn and lined, sometimes even in the young. It is usually pale, though in some the face is ruddy, and the nose is red in cold weather. The hands are usually cold; and they tell you their circulation is feeble. They are always worse on raw, cold days, and feel chilly and ill after a cold bath.

Cold hands are sometimes associated with a peculiar roughness and thickness of the skin. The fingers may become white and numb; "dead" is the term often applied. Exposure on a very cold day may cause the condition to be so extreme that pain in the finger-ends is very severe; and in one case I have seen a slight gangrene follow. The nose is often red, and the association between dyspepsia and the red nose is extremely common in these individuals. There is very often dilatation of the stomach, associated with accumulation of blood in the abdominal veins. This latter can be demonstrated by pressure on the abdomen, when the jugular vein becomes full. In some cases the increased swelling and pulsation of the jugular vein can be seen to occur during quiet respiration, the swelling of the vein occurring during inspiration. The cause of the swelling in this condition is that pressure on the abdomen empties the abdominal veins into the right heart, so that there is less accommodation for the blood returning by the superior vena cava; hence the jugular vein distends. Inspiration causing a descent of the diaphragm compresses the abdominal contents, including the large veins, against the unyielding wall, and brings about the same result.

The heart itself in these cases is sometimes slightly

dilated; and there may be mitral and tricuspid systolic murmurs. They are very evanescent, present one minute and gone the next. Sometimes we can detect them at the beginning of an examination, and in a very few minutes they have disappeared. The date and rhythm of the heart may vary. Sometimes it is rather slow, and sometimes it is irregular, the irregularity usually being respiratory, though occasionally extra systoles are present; and then the patient, if conscious of them, is often greatly frightened, particularly if the doctor does not convincingly reassure him. Hesitation or doubt on the part of the doctor hangs like a cloud over the patient. On account of the presence of some of these symptoms, these cases are often mistaken for cases of heart disease, and many individuals in consequence are subjected to prolonged treatment, which, being ineffective, depresses the patient, interferes with his business affairs, and may send him all over the world in search of a " cure." I have never seen heart failure occur in any of these cases; and this assurance is often more effective than any special form of treatment.

I have been particularly struck with the slow respiration in a number of these cases. It may fall as low as seven per minute, and the patient may be free from any distress and quite unconscious of any trouble. It is then that the heart rhythm is most affected, and the swelling of the vein during inspiration and from pressure on the abdomen occurs most characteristically. The nature of this irregularity is fully described in Chapter XXVI. A healthy individual can sometimes produce this irregularity by simply breathing slowly and deeply, at the rate of seven or eight per minute.

The complaints are extremely varied, and many have a fixed idea that certain organs are at fault; and it is true that some trouble, usually slight, may be found in some organ. Thus we find gastric and bowel complaints

extremely common, though other viscera may also be at fault and complained of. The patient's mental condition is curious and interesting. Some of them are sane, level-headed, and extremely intelligent. To others the bodily suffering is nothing more than a grevious and troublesome affliction. In others it leads to irritability and peevishness of temper. Some become introspective, and are deeply concerned with their bodily or spiritual affairs. It alters their views of material things; cranks and faddists, political, religious and dietetic, are common amongst them, often exhibiting strenuous enthusiasm for their particular ideas. Another astonishing feature in these cases is the remarkable way in which a temporary recovery may take place. For weeks some of these individuals may go about miserable and ill, taking little food, finding that little too much for the digestion, and searching for some kind that will suit them—when suddenly they feel better. Their recovery may last for weeks or even months, but they generally relapse.

Now this peculiarity leads to another characteristic of the complaint—unbounded and unreasoning belief in what they take to be the cause of their recovery, diet, drug, methods of exercise, operation. It is because of this tendency to recover that there are so many cures. If one reads between the lines of the testimonials in favour of certain remedies, empiric or recognised by authority, we can see that it is this class of case that is being treated. It is especially among them that the faith cures abound; and these are the people who swell the ranks of Christian Scientists. Emotional excitement, whether of love or religion, always relieves this kind of person; and so when religion comes into play we get the various forms of faith-healing. Many women feel extremely well when pregnant.

The diagnoses of medical men are as numerous and

varied as the complaints of the patient. The gynæcologist diagnoses some pelvic disorder ; the surgeon sees the source of all the trouble in the appendix, a dilated stomach, or a wandering kidney ; while the physician recognises the disease according to the bent of his studies—a heart affection, visceral stasis, gastroptosis, neurasthenia, atonic dyspepsia, and so forth. So minute, indeed, are some of the diagnoses that we find them classified further as cardiac, gastric, mental, or renal neurasthenias.

The cause of the X complaint.—Although I have sought long and earnestly for an explanation of this complaint, I must confess that I have but an imperfect knowledge of its origin. As I say, it never leads to heart-failure or to death, so that its cause can only be one of speculation. Seeing it is so often associated with digestive troubles, it at once occurs to the mind that it may be due to an absorption of a toxic substance from the intestines. In support of this view is the fact that it is often associated with constipation and dilatation of the stomach. It is seen very typically in cases of gastric ulcer, especially occurring at the pyloric orifice, with pyloric stenosis and dilatation of the stomach. So frequent is this association that I always examine my patients carefully for gastric ulcer. I have seen several cases greatly improved after a gastro-enterostomy has been performed ; and treatment directed to the digestive tract is the one that I have found most beneficial on the whole. Nevertheless, there are cases in which we can detect no digestive trouble, and in some we get other visceral affections. Thus I have seen the condition acquired in people who have had much suffering for years from other complaints, as renal calculus. There is no doubt that several different complaints are included in this description, but so far it is not easy to see on what grounds we should separate them.

CHAPTER V.

In order to throw more light on the mode of evolution of bands and other changes in the abdominal cavity, Dr. James Mackenzie has suggested to me that I should include here two of the many papers I wrote on the evolution of the skeleton and soft parts of the body nearly thirty years ago.

I am doing it with some reluctance, since I fear that few readers will have the patience to plod through details which may not, at first sight, appear to them to bear on the subject.

These two papers concern the changes that develop in the coal-trimmer and the shoemaker, to which I have alluded very briefly in the beginning of this book.

A REMARKABLE EXAMPLE OF THE MANNER IN WHICH PRESSURE-CHANGES IN THE SKELETON MAY REVEAL THE LABOUR-HISTORY OF THE INDIVIDUAL.*

In the ' Transactions of the Pathological Society,' 1886, I published a paper on the " Causation and Pathology of the so-called Disease Rheumatoid Arthritis and of Senile Changes." In it I showed that the changes which are described as being characteristic of the presence of this

* 'Journal of Anatomy and Physiology,' 1886-1887.

so-called disease are the results of purely physiological processes.

They form a very complex group, and depend for their existence upon pressure in some form or another, the term pressure being used in a very wide signification.

I was able to subdivide them into the four following classes :

1. Changes which result from the exercise of enormous pressure *at one time*, as, for instance, those which ensue in the head of the humerus or of the femur after falls upon the shoulder or hip.

2. Changes which result from the *frequent* exercise of very considerable pressure over a long period of time, as in labourers who carry heavy loads upon their heads, backs, or shoulders, or in those who are affected with some deformity which alters the normal mode of transmitting the weight of the body to the lower extremities, as in shortening of one leg from fracture or disease. In such a case, changes are most marked in the hip and sacro-iliac joints on the affected side, the spinal column also showing alterations dependent on the deformity.

3. Changes which ensue in old age from the acquired condition of habitual flexion of the trunk and limbs, and the limitation in the extent of articular movements consequent on the absence of the movements of extension, abduction, and extreme flexion.

Many of these changes are due, not so much to pressure, as to the absence of accustomed pressure. This is seen in the filling up of the floors of the olecranon and coronoid depressions by the deposit of layers of bone upon it so as to form an osseous elevation, or by the formation of a pedunculated mass of bone in a fringe of synovial membrane.

Many other changes consequent on the partial or complete dislocation of several joints also occur in old age.

4. Severe attacks of subacute or chronic rheumatism place the affected part in a condition which is identical with that present in old age, and changes ensue which are similar in character to those then present, though they vary with the vitality of the osseous system of the individual.

I showed that the manner in which bone and cartilage react to pressure depends to a very great extent upon the vitality of those tissues; that the pressure which in elderly subjects or in those of low vitality destroys the articular cartilage and the subjacent bone, rendering the latter eburnated, and determining the formation of additamentary bones, produces in a young subject a similar alteration in the form of the articular surface, without affecting the vitality or continuity of its cartilaginous covering.

I also pointed out that, if you increase the extent of the movements permissible in an articulation, the synovial membrane and periosteum beyond the margin of the original articular surface form bone and articular cartilage, which are identical in function and character with that already present, and that if you limit the movements of a joint, or if partial or complete displacement of the opposing cartilaginous surface is produced, that portion of the articular cartilage which no longer receives the accustomed friction and pressure of that originally opposed to it becomes converted into synovial membrane and areolar tissue.

The above four subdivisions will include all changes which ensue as the result of pressure, and these I have designated by the term *pressure-changes*. The conditions which are usually regarded as characteristic of the disease *rheumatoid arthritis* are included as a sub-class of *pressure-changes*. In a paper in the 'Guy's Hospital Reports,' 1886 (" Pressure-Changes in the Trunk and Shoulder Girdle "), I have given many instances of these pressure-changes,

and I have added many more in the paper in the ' Patho-
logical Transactions' alluded to.

Since writing those papers I have steadily pursued the
study of the subject, with the satisfaction of being able to
verify hypotheses which I may have put forward then with
some slight hesitation, and to satisfy myself still more
absolutely as to the accuracy of the views which I have
expressed on the subject of the causation of rheumatoid
arthritis.

I will now give the following very interesting example
of the manner in which the presence of pressure-changes
in the skeleton may enable us to detect the habits and
labour-history of the individual. In this description, and
for the future, I will limit myself to the use of the term
pressure-changes, avoiding altogether the use of the less
comprehensive and vaguely definable term *rheumatoid
arthritis*.

Since this is the first instance of this particular group
of changes which I have yet observed, I must state at once
that, as I have not had an opportunity of verifying the con-
clusions at which I have arrived, I will therefore put them
forward hypothetically and subject to the result of future
experience. At the same time, I may say that I have no
doubt, in my own mind, that subsequent investigations will
serve to verify them.

The body was that of a man who died at the age of
sixty-nine of chronic bronchitis. He was largely and
powerfully built, and his bones and muscles were in very
good condition. It was evident, from the general appear-
ance of his bones and joints, that he had been employed at
some form of active and heavy manual labour for many
years of his vigorous life.

The *sternum* was strong and thick. The manubrio-
gladiolar articulation was firmly amphiarthrodial in
character, and, though the opposing surfaces of the bone

were broad, they were not so dense as is usual in labourers who carry loads upon the trunk. There were no so-called additamentary bones in the back part of the joint.

The *clavicles* were very thick and strong, and their outer thirds were particularly deep. Their inner extremities, especially that of the right clavicle, extended downwards, backwards, and inwards to a greater extent than in any that I have yet observed. The clavicular facets on the manubrium presented a corresponding change in their form and direction. This condition, which was obviously an exaggeration of that normally present, appeared to have been developed with the object of preventing forward displacement of the inner extremity of the clavicle, when its outer extremity was forced backwards and perhaps upwards by a pressure of no small amount.

The margin of the facet on the under surface of the inner extremity of each clavicle was everted and lipped. The rhomboid ligament was very dense and broad, and there was no indication of the formation of a bursal cavity in relation with it, nor was there any displacement of the insertion of the subclavius muscle. These facts show that the weight, which had been habitually applied in a downward direction to the outer extremities of the clavicles, though considerable, was not so great as in labourers who sustain loads upon their trunks. This is also shown by the circumstance of the first costal cartilage being but partly sheathed by bone. The movements permitted by the sterno-clavicular articulation were very free within certain limits.

The *scapulæ* were strong, and the acromion process was thick. The corresponding facets on the acromion and clavicle were large, and though the fibro-cartilage which usually intervenes was completely absent, the margins of the facets were not lipped. They were connected by loose fibrous capsules. The coronoid and trapezoid ligaments

were short and strong. A bursal cavity existed in front of these ligaments on the right side, but it was not so well developed as in labourers who carry loads upon their trunks—who retain the shoulder - joint in a position of complete flexion in order to support the load.

These facts show that the scapula was moved freely upon the clavicle, and that the movement of extreme flexion of the right shoulder-joint occurred very frequently. It is also extremely probable that the arm was loaded during the performance of these movements.

The *shoulder-joint* presented some changes. The long tendon of the biceps passed freely through the bicipital groove and ended in the glenoid ligament. On the right side the glenoid ligament was separated completely from the upper third of the margin of the glenoid cavity, being connected to it indirectly by a thin membrane. The upper part of the glenoid cavity was slightly increased in area. The cartilage covering the lower part had been converted into synovial membrane and areolar tissue, which formed an elevation whose surface projected beyond the level of the articular cartilage. These changes were present on the left side in a slighter degree.

Now, the above conditions are found associated with the upward displacement of the head of the humerus which ensues in old age, but in this subject the abductor muscles, like the other muscles of the shoulder, were remarkably well developed, and there was no change in the form of the upper extremity of the humerus. I think we may conclude from this that the upward displacement of the head of the humerus was due either to the raising action of the flexor muscles and deltoid, or to force or resistance exerted upwards in the direction of the shaft of the humerus, or to both acting together.

The *elbow - joints* showed well - marked and peculiar pressure-changes. The articular cartilage covering the

trochlear surface of the humerus and of the ulna was thick
and normal in appearance, in no part presenting any

FIG. 80.—Right elbow-joint of coal-trimmer.

degenerative change. The area of the opposing articular
surfaces of ulna and humerus was extended by marginal
bony growth, the surface of which was covered by articular
cartilage, which was continuous and identical in character
with the original articular layer (see Figs. 80, 81, and 82).

Besides this increase in articular area, the olecranon and coronoid depressions were filled up to a great extent by bone, so that the left forearm could not be extended on the upper arm beyond an angle of 155°, nor could it be flexed beyond an angle of 75°. On the right side the
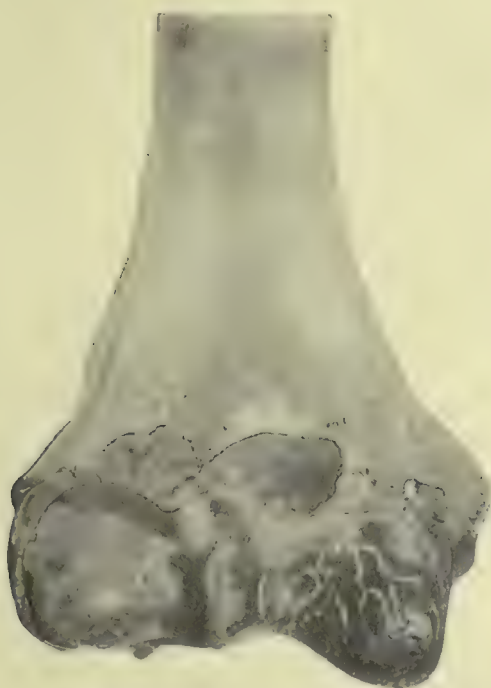
FIG. 81.—Lower end of right humerus of coal-trimmer.   FIG. 82.—Upper end of right radius of coal-trimmer.

movements of flexion and extension were still more limited. The margins of the coronoid and olecranon processes were rendered very thick, and these presented flat, eburnated surfaces, which articulated in extreme flexion and extension with corresponding facets formed on the masses of bone which filled up the floor of their corresponding fossæ.

It is obvious that the increase in breadth and strength of the area of the humero-ulnar articulation took place in

order that the elbow-joint might be rendered strong and
firm, so that the forearm supporting a considerable load
could be rapidly flexed on the upper arm with ease and
safety to the elbow-joint through an angle of 80°. The
filling up of the floors of the olecranon and coronoid
depressions with bone, and the increase in the thickness of
the extremities of the olecranon, and especially of the
coronoid process, and the remarkable eburnation of the
opposing surfaces of coronoid process and of the bone
filling up the coronoid depression, show that in the per-
formance of his occupation it was never necessary to flex
or extend the forearm completely, that the limited move-
ment though about 80° was the normal one, and that this
limitation in movement round a transverse axis was advan-
tageous in rendering the elbow-joint stronger and more
reliable for its acquired function.

The radial head of the humerus differed in a very striking
manner from that of the trochlea. The thick layer of
articular cartilage which covered the latter surface termi-
nated abruptly on the margin of the radial head, whose
surface was completely deprived of cartilage, and was,
instead, densely eburnated and polished. Much of the
original articular lamella of bone had been removed, and
this had evidently been the result of the friction and
pressure exerted by the head of the radius upon it.

Filling up the little fossa above the radial head and
limiting flexion of the forearm was a boss of bone which was
facetted and eburnated by the margin of the radial head.
The upper surface of the head of the radius was completely
deprived of its articular cartilage. It was deeply cupped,
eburnated, and polished. It was not uniformly concave,
there being a slight elevation in front. On placing the
parts in position, it was seen that the movements permitted
by the radio-humeral articulation was one of flexion
through a limited angle, associated with one of rotation of

the shaft of the radius through about 100° F., so that the hand was carried from the supine position to one of pretty complete pronation.

From the amount of polished eburnation of the opposing surfaces of the radius and ulna, it is obvious that very much force was exerted upon the radial head of the humerus by the head of the radius. This may have been due to resistance to the forward movement of the hand, or to a heavy load carried in the hand during the movements of flexion and rotation, or to both together. The last appears most probable from the examination of the character and arrangement of the eburnated surfaces.

The sigmoid cavity on the ulna was considerably increased in area by the deposit of bone on its posterior margin, and in such a way as to change the general direction of its concave surface, so that it no longer looked outwards, but outwards and forwards. Attached to the anterior limit of the facet was a concave mass of bone, which continued the direction of its concavity. This mass was connected to the sigmoid cavity by ligamentous tissue, and formed a so-called additamentary bone. Like all these so-called additamentary bones, it was not a symptom of a so-called disease, but it served a definite and useful physiological function. When the forearm was extended to nearly its extreme limit upon the upper arm, this so-called additamentary bone formed a portion of the socket for the head of the radius, and as the angle between the forearm and upper arm was diminished, this portion of bone was gradually displaced upwards, but in doing so it still formed a part of the socket, in which the head of the radius could rotate without its flexion being interfered with by its presence.

The margin of the radial head was smooth, and covered by cartilage over nearly three-fifths of its area, this smooth surface being limited in front and behind by marginal bosses, which also limited the rotation of which the radius

was capable. The non-articular margin presented at its lower part irregular bossing of bone.

In the *lower radio-ulnar articulation* the area of the opposing facets was limited, the margins being abruptly defined and prominent. They were covered by a thin layer of auricular cartilage. The interarticular fibro-cartilage was perforated along its attachment to the margin of the radius, except where it was continuous with the anterior and posterior inferior radio-ulnar ligaments. The head of the ulna was seen through the perforation in the fibro-cartilage.

In some labourers I have seen this fibro-cartilage completely removed, and the opposing surfaces of cuneiform bone and ulna densely eburnated. This perforation is obviously due to force acting on the radius, displacing it a little upwards, and pressing upon and destroying the tense fibro-cartilage.

The *thorax* was well made and typically masculine in character. The first pair of ribs were strong, but not very broad. On pressing on the first costal arch in a downward direction no tilting was obtained, its articulations with the column being particularly firm and allowing of very little movement.

The first rib on the right side articulated with the spinal column in a manner which I had never before seen (see Fig. 83). Two prominent bony processes projected outwards from the bodies of the seventh cervical and first dorsal vertebræ in such a manner as to enclose between them the head of the first rib, for which they formed a socket. This socket only permitted of a rotation of the rib around the transverse axis of its head. The process of bone which projected from the body of the seventh cervical was much the larger. It was more than half an inch long and very dense. It altogether opposed any upward movement of the head of the rib.

The connection of the rib to the transverse process of the first dorsal vertebra was very strong, and allowed of very limited movement. Though the connection of the left first rib with the column was very firm, there was no new bone formation as on the right side.

The appearances presented by the right costo-vertebral articulation were altogether different from those seen in labourers who carry loads upon their trunks. In them, the head of the rib is large and flat, and allows of considerable movement in some cases, as it receives the powerful pressure transmitted to it through the clavicle.

FIG. 83 is a diagram showing the new joint for the head of the first rib. 1 and 2 indicate the transverse processes of the seventh cervical and first dorsal vertebræ respectively. The transverse process and first rib on the left side are not represented in the diagram.

In this case, then, it would appear that the character of the work performed necessitated a very considerable fixation of the first costal arch, and especially of its right half, so that the right clavicle might have a firm or even rigid base to work upon. Also, that the amount of force transmitted to it by the clavicle was not enormous, though probably considerable, and that the movements performed by the first costal arch were almost solely respiratory, the anterior extremity of the rib moving upwards and downwards in a vertical plane around a transverse axis, which passed through the head and tuberosity of the rib.

The *cervical column* showed no pressure-change, its

anterior surface being quite smooth and its fibro-cartilages
intact.   This circumstance alone would at once remove any
possibility of the man's having carried heavy loads upon
his trunk.

The *dorsal column* presented two slight lateral curves.
The upper was formed by the upper five or six dorsal
vertebræ and the sixth and seventh cervical.   Its con-
vexity was directed to the right.   The lower was formed
by the remaining dorsal vertebræ and the first and second
lumbar vertebræ.   Its convexity was directed to the left.
The right and anterior margins of the bodies of the ninth
and tenth dorsal vertebræ were connected by a prominent
boss of bone, which presented a slightly serrated suture.
The adjoining margins of the tenth and eleventh vertebræ
were lipped by the formation of some marginal bony
growth.   The intervertebral fibro-cartilages between these
several vertebræ were normal, and showed no signs of
being compressed, and, except in the case of that which
was bridged over by bone, they allowed of very free move-
ments of flexion and extension of the column.

The *lumbar curve*, examined in its entirety, was of an
average convexity ; but on examining its anterior surface
more carefully, while the subject was in the supine position
with the trunk completely extended, it was seen that the
curve formed by the upper four lumbar vertebræ termi-
nated abruptly on a plane anterior to that of the fifth
lumbar, the fourth vertebra appearing to be displaced a
little forwards from the upper surface of the last lumbar
vertebra and sacrum.   The intervertebral substances
between the several lumbar vertebræ and sacrum were very
thick, and allowed of the column being freely flexed and
extended.

The adjoining lateral and anterior margins of the bodies
of the fourth and fifth lumbar vertebræ were much lipped
by the deposit of new bone upon them.   This was much

more abundant towards the sides than in front, and on the
left side than on the right, and on the upper margin of the
fifth vertebra than on the lower margin of the fourth.

On moving the thorax an extraordinary amount of
rotation was seen to take place between these two vertebræ,
and careful examination showed that the movement that
had been habitual during lifetime was one of rotation
of the thorax and upper four lumbar vertebræ to the left,
and when this movement of rotation had been rendered as
complete as possible, the shelf of bone which projected
from the left upper margin of the body of the fifth lumbar
vertebra served to support the partly displaced fourth
lumbar vertebra.   In this joint, then, besides a partial
forward displacement or spondylolisthesis, a partial lateral
displacement was also permitted.

It was apparent that this form of labour necessitated a
powerful rotation of the thorax to the left upon the pelvis
and fifth lumbar vertebra, that very much of the lateral
flexion of the column also took place at this point, also that
the trunk was more frequently flexed to the right than to
the left, and that the trunk was loaded to a certain extent
during the performance of these movements.   The lower
of the two lateral dorsal curves was probably due to this
frequent lateral flexion of the trunk obliquely to the right,
and I considered that the upper lateral curve, with its con-
vexity directed to the right, was compensatory and secon-
dary to the lower one.

It was obvious, from the amount and variety of move-
ment permitted between the bodies of the fourth and fifth
lumbar vertebræ, that the articular processes and laminæ
of these vertebræ must have undergone very considerable
modifications.   On examining the posterior aspect of the
column, I found that the interspinous and supraspinous
ligaments were very dense and strong, and, at the same
time, remarkably pliant, so that they did not oppose any

obstacle to extreme flexion and extension of the column.
The spinous processes were large and broad, and, though
deep, they were not so deep as they are in labourers who
carry loads upon the head or shoulder. They also allowed
of very complete extension of the lumbar spine. The
spinous process of the sacrum was large and prominent,
and in complete extension the spine of the fifth lumbar
vertebra rested upon it.

On cutting into the interspinous ligaments connecting
the second, third, fourth and fifth vertebræ large synovial
cavities were found in their substances, so that the inter-
spinous ligaments formed strong elastic capsules, which
connected the opposing surfaces of the spinous processes.

The cavity between the second and third spinous pro-
cesses was larger than that between the fourth and fifth,
while the cavity between the third and fourth was very
large, the opposing surfaces of bone being densely ebur-
nated. This articular cavity extended forwards between
the opposing laminæ. The spine and lamina of the fourth
lumbar vertebra were then felt to be disconnected from the
body, and on dividing the column in the middle line (Fig. 84)
it was seen that the spine, lamina, and inferior articular
processes of the fourth lumbar vertebra were separated
from the body, pedicles, and superior articular processes.
The several parts of this vertebra in median section are
shown in position in Fig. 85. The upper surface of the
lamina was eburnated. The fibro-cartilage between the
fourth and fifth vertebræ was of normal thickness, and
though it allowed of pretty considerable forward displace-
ment of the fourth vertebra, especially when the column
was flexed, it also allowed of its complete replacement
when the column was completely extended. A small
articular cavity was present in the substance of the carti-
lage. Though the intervertebral foramina were encroached
upon, the nerves contained in it were not compressed. It

was evident that at one time during the labour the thorax had been flexed on the pelvis, and that at another the column had been very forcibly extended.   Besides articu-

FIG. 84.--Vertical median section of lumbar and sacral vertebræ.

lating with the under surface of the lamina of the third lumbar vertebra, the upper surface of the lamina of the fifth lumbar also articulated with the eburnated under surface of the pedicle and superior articular process of the fourth lumbar, and with a flattened eburnated facet on the under surface of the inferior articular processes of the third lumbar vertebra (see Figs. 84 and 85).

The facet which had originally existed on the inferior articular process had been completely altered in form by its extension upwards to the upper margin of the lamina. The articular surface was convex transversely, and looked forwards and very slightly outwards. This articular surface was continuous around a right angle with the eburnated upper surface of the lamina.

The superior articular processes of the same vertebra, which were connected to the pedicle, were considerably in-

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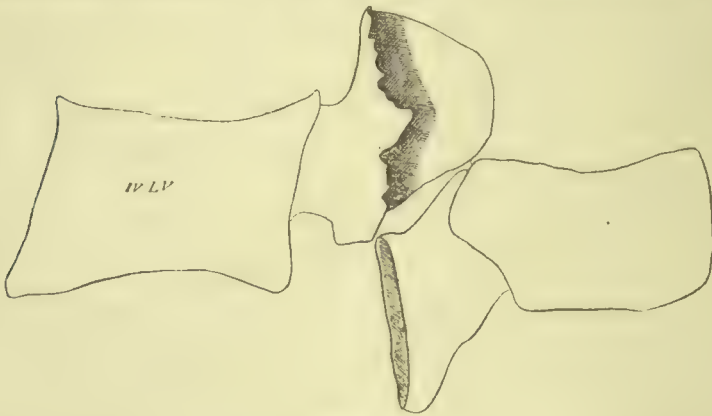
FIG. 85.

creased in depth and altered in form. The articular surface, regarded as a whole, looked backwards and inwards, but the anterior limit of this facet had been continued inwards and then slightly backwards, terminating in an irregular margin. By this means, the concavity of the anterior part of facet looked backwards and even slightly outwards. The upper extremity of this process was flattened and eburnated, and fitted into a deep depression which it had worn for itself in the pedicle of the third lumbar vertebra. The under surfaces of the pedicle and superior articular process were flattened and eburnated, and articulated with the superior articular processes of the fifth lumbar and with the lamina of the fourth. The inferior articular processes of the third

lumbar were elongated.   Their articular surfaces were also much increased in area.   They were convex transversely, and in front were directed forwards, while posteriorly they looked outwards.   If was quite obvious that the increase in the area of their articular surfaces was the result of the excavation of the pedicle of this vertebra by the pressure exerted upon it by the extremity of the articular process of the vertebra below.   The under surface of this articular process (the inferior of the third lumbar) was broad, flat, and eburnated, and it articulated with the upper surface of the lamina of the fourth lumbar vertebra and with the flattened upper extremity of the *superior articular process of the fifth lumbar*.   The superior articular process differed but slightly from the normal.

The superior articular processes of the fifth lumbar were very thick and strong.   Their upper extremities presented large flat semilunar eburnated facets, which articulated with the under surface of the pedicles of. the fourth lumbar, and with the lower flattened extremities of the *inferior articular processes of the third lumbar*.   Its articular surface had been very much increased in depth by the excavation of its lamina by the extremity of the inferior articular process of the fourth vertebra in extreme and forcible extension of this portion of the column.   The surface was concave transversely, and was directed backwards, its posterior part being directed inwards.

The articular surfaces on the articular processes of the last lumbar and first sacral vertebræ were increased in area in a similar manner, but to a much less extent.

I have described all these changes in detail for reasons which will be obvious.   Examining the articulation of the last lumbar vertebra and sacrum, and the form of the several parts of the sacrum, it is seen that the movements that took place between these bones were those of considerable flexion and extension.   It is probable that both these

movements were exerted with very considerable force, especially that of over-extension, since the spinous process of the sacrum and that of the last lumbar vertebra were thick and dense. The form and density of these processes, if examined alone, might have led one to imagine that the subject had been a labourer who carried loads upon his head or shoulder. An examination of the curve of the front of the sacrum, and of the condition of the fibro-cartilage between the sacrum and last lumbar vertebra, at once excludes this possibility. Therefore, we may safely conclude that movements of flexion and considerable extension took place between these bones, also that the latter movement particularly was carried out with considerable force.

If we examine the connections of the third, fourth, and fifth vertebræ to one another, we gather, from ·the condition of the fibro-cartilages, the connection of the spinous processes, and the deep excavation of the pedicles and laminæ by the extremities of the articular processes, that movements of flexion and extension took place freely and frequently between these vertebræ, and that the movement of over-extension was carried out with much force.

We also see that, while in the third and fifth vertebræ the movements of loaded over-extension, if I may so express myself, have only resulted in a considerable excavation of the pedicles of the upper vertebra and of the laminæ of the lower, in the case of the fourth vertebra the upper articular processes of the fifth lumbar vertebra and the lower articular processes of the third lumbar have by this process of gradual excavation completely severed the spine, lamina, and lower articular processes from the remainder of the vertebra, *and articulated with one another*. I have already described in previous papers other examples of this process of section of vertebræ by pressure, but in those cases the last lumbar vertebra was the one always affected.

An examination of the altered form of the surfaces on the adjoining articular processes of the third, fourth and fifth vertebra shows that a very considerable amount of rotation took place between these vertebræ. After the division of the fourth lumbar vertebra into two parts by the pressure exerted upon it by the articular processes, a new joint was formed which admitted of extremely free rotation. It was formed *above* by the under surface of the spine and lower articular processes of the third lumbar vertebra and by the excavated inferior surface of the pedicle of the fourth vertebra, and *below* by the spine and lamina of the fourth and superior articular processes of the fifth vertebra. These opposing surfaces were densely eburnated and polished, and were connected by a loose elastic capsule. As we have already seen, the fibro-cartilage between the fourth and fifth vertebræ was very thick and elastic, and readily allowed of very considerable rotation of one vertebral body upon another.

The margins of both *sacro-iliac joints* were slightly irregular, and the upper portions of the intervening cartilages had been divided and partly removed. These joints allowed of considerable flexion and extension movements, the latter being more freely permitted. At the same time it was apparent that during these movements the trunk had been moderately but not excessively loaded. The left joint showed more change than the right.

In the *left hip-joint* the area of the upper margin of the articular cavity immediately below the anterior inferior spine was extended by the deposit of bone and cartilage upon it. The head and neck of the femur presented in a moderate degree those flexion changes I have already figured and described (" The Causation and Pathology of the so-called Disease Rheumatoid Arthritis and of Senile Changes "). The movement which had been performed habitually in this joint appeared to have been one of oblique

rather than simple flexion. Here, again, it was obvious
that during the performance of these movements in this
joint the body had not been excessively loaded, though it
had been considerably so (see Figs. 86 and 87).

Fig. 86.—Anterior aspect of upper extremity of right femur of coal-trimmer.

The *right hip-joint* showed very slight flexion change.

The lungs and bronchial glands contained much black
pigment.

I will now state the conclusions which we are able to
arrive at from the examination of the bones and ligaments
of this subject.

We are at once able to exclude all those forms of labour
which I have already observed and described, namely :

(*a*) Those in which the load is carried upon the head or upon the shoulder. In this group, the centre of gravity of the load and trunk corresponds in its position in relation to the pelvis to that of the unloaded trunk.

(*b*) Those in which the load is carried upon the back of

Fig. 87.—Posterior view of upper extremity of right femur of coal-trimmer.

the head, neck, and trunk. In this group the centre of gravity of the loaded trunk falls in front of the normal.

(*c*) Those in which the load is carried in the hands, as in the milkman, and those which I have not yet described in which the load is carried more apparently in front of the trunk, as in pregnant women, women carrying children in their arms, and in occupations in which a load is supported in the front of the trunk. In this group the centre of gravity of the loaded trunk falls well behind the normal.

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It is apparent that this man has for very many years, very probably during the whole of his vigorous adult life, performed the same form of labour, and that the labour was peculiarly routine in character. By the labour being routine I mean that it consisted of certain successions of movements, each succession differing from the preceding one in no important particular.

It is also obvious that the various movements which made up a succession were very different in character, and that in all of them the trunk was loaded to a moderate extent. In some of them the load or force resisted was relatively great, while in others it was relatively small. For instance :

(*a*) The movements of over-extension of the spinal column were very free, and had been carried out with very considerable force, so that we may conclude that, during the over-extension of the trunk, the load lay behind the vertical plane of the trunk so that the combined centre of gravity of trunk and load fell behind that of the normal trunk.

(*b*) Also, during the movement of flexion of the thorax upon the pelvis the load lay in front of the body, the common centre of gravity of load and trunk lying in front of that of the trunk alone. During the movement of flexion the load did not produce the same marked result as it did in the movement of extension, therefore it was practically not so heavy.

(*c*) Also, besides the movement of simple flexion, those of oblique flexion very frequently occurred. These were in the large majority of successions directed to the right, though the oblique movement to the left was by no means infrequent.

(*d*) The thorax and load were rotated to the left with very considerable force, and to a very great extent. The force exerted in performing this rotation of the trunk must

have been very great, therefore it is extremely probable that the rotation was produced in part by the impetus given to the body by a moving load which rotated around the same axis as the trunk. The load would therefore pass from the front of the trunk to the left of it and then well behind it. The first and last of these movements we have already observed.

(e) While the trunk was flexed upon itself, the pelvis was flexed upon the left thigh, which was rotated outwards to a considerable extent. Very much more strain was exerted upon the left than upon the right hip-joint.

(f) Very great resistance was experienced by the hand and forearm when forced forwards with very considerable force. This movement took place when the trunk was flexed upon itself and upon the left thigh.

(g) The forearm, loaded by a considerable weight, was then flexed upon the upper arm.

(h) The right upper extremity and load was flexed very considerably at the shoulder-joint.

(i) The small extent of angular movement permitted in the right elbow-joint, as compared to that of the left, and the knowledge we already possess that the load, while somewhat rigidly attached to the trunk, was carried in a semicircle around it, suggests that the load could not have been supported directly by both hands, but indirectly by means of some rigid support, as, for example, a load of any heavy material supported upon a spade or shovel, the handle of which was held in the right hand. Putting together the several movements that form this succession, I concluded that during the whole of his active life this man had been continually occupied in shovelling some material which was very coarse, in the sense of offering resistance to the passage of the spade through it, and also very heavy, from the level of the ground, and throwing it some considerable distance behind him and to his left.

The occupation of filling carts with gravel or coal then

appeared to me to be the most likely, yet I was doubtful, from an observation of such labourers, whether such an occupation would give the very extensive and free rotation of the thorax which this skeleton apparently indicated.

As I have been so frequently unsuccessful in my attempts at obtaining the labour-history of the individual, during his active life, from the authorities of the institutions from which our subjects come, I had neglected to write for information in this case. I then did so, and the medical officer very kindly informed me that his last occupation had been that of ship-keeper. By inquiring I then found out that among the men who were most frequently employed as ship-keepers were old ship's-carpenters or trimmers, who had served for a long time and who had got good characters as being steady and good workmen. Now, a ship's carpenter would not have suited my purpose at all, for the reason that he is practically a jack-of-all-trades, and is not occupied in a sufficiently routine manner. However, the trimmer was just the man I wanted. As the reader is possibly as little familiar with the habits of this class of labourer as I was, I will briefly sketch out their form of labour. In the coaling of the ship the trimmer is a very important individual, for it is his duty to arrange the coal, after it has been thrown down, in such a manner that the ship's equilibrium may be stable. This requires very considerable skill, as many ships require to be trimmed in a particular manner, and this manner may be varied under different circumstances. Consequently the labourer devotes himself to this peculiar form of labour and does nothing else. He commences it at an early period of his life, and he must necessarily be very powerfully built, as he has to shovel the coarse coal and to throw it enormous distances, and the force exerted in doing this is very great indeed.

I think that if the reader has followed me step by step through the several anatomical details, he will agree with

me as to the correctness of the conclusion at which I have arrived. I hope that I have not neglected to explain any of the anatomical details which, though familiar to me from continually examining, observing, and analysing them, may not be so patent to those who have not devoted so much time and attention to the subject.

Before leaving the consideration of this case, I will call particular attention to one or two details which are of special interest.

In those forms of labour in which a heavy load is borne upon the rigid trunk, and the weight of the load and trunk is transmitted to the pelvis through a vertical median plane, I have shown that the constant pressure exerted by the inferior articular processes of the fourth lumbar vertebra and by the superior articular processes of the sacrum upon that portion of the arch of the fifth lumbar vertebra which lies between their extremities, may cause its partial or complete section. The posterior segment which results from this section consists of spine, lamina, and inferior articular processes, while the remainder of the vertebra forms the anterior segment. In such labourers no obvious movement of rotation around a vertical axis takes place between the fifth lumbar vertebra and the sacrum. Now, in the case I have described in this paper, the fourth lumbar vertebra has been divided in a very similar, though not in the same identical, manner, and for this reason that the occupation of the individual required that the thorax and load be forcibly rotated upon the pelvis.

Under such circumstances it is obviously advantageous that this rotation should take place as low down as possible in the column. It is impossible for this movement of rotation to take place between the fifth lumbar vertebra and sacrum, owing to the firm connection of the former bone to the pelvis, so that the next possible seat of chief rotation must be the articulation of the fourth with the

fifth lumbar vertebra. It is apparent that the normal formation of the articular processes of these vertebræ would not allow of any very extensive rotation, consequently the form of the processes and the direction of their articular surfaces require considerable modification.

The examination of the lumbar spine in my case showed that, before the arch of the fourth lumbar vertebra had been cut through, the undivided fourth lumbar vertebra rotated freely upon the subjacent vertebra, and the forms of the articular surfaces on the opposing articular processes had undergone very considerable alterations so as to allow of this exaggerated movement.

Owing to the vertical pressure exerted by the extremities of the upper articular processes of the fifth vertebra upon the arch of the superjacent vertebra at the bases of the facets on its inferior articular processes, during overextension of the spine, and owing also to the transverse cutting movement exerted by the same processes during the violent rotation of the column, the articular surfaces on the inferior articular processes of the fourth vertebra were gradually extended upwards at the expense of the arch of the vertebra. A similar process produced an increase in the area and direction of the facets of the superior articular processes of the fourth vertebra, also at the expense of the vertebral arch. The arch was finally completely cut through in two points by the rapid destruction of its lower margin and the more gradual removal of its upper margin. The less rapid destruction of the upper margin was due to the less extensive rotation which took place between the third and fourth lumbar vertebræ.

After the fourth lumbar vertebra had been divided into two distinct parts, the anterior of which comprised the body, pedicles, and superior articular processes, and the posterior, the remainder of the vertebra, rotation then took place between the body and excavated pedicle of the fourth

lumbar vertebra, the inferior articular and the lower margin of the spine and lamina of the third lumbar above, and the body and superior articular process of the fifth vertebra, and the upper margin of the spine and lamina of the fourth vertebra below. I have frequently seen the earlier stage of this condition resulting from over-extension and excessive rotation in bodies I have dissected of subjects affected with hip disease in early life, and in which there had been much shortening on account of the femur becoming ankylosed to the innominate bone at an angle, also in cases of united or ununited fracture of the neck of the femur, in which there was considerable shortening. In such cases it becomes necessary, in order to maintain the equilibrium during walking, that the pelvis and shortened limb be rotated very forcibly upon the upper part of the trunk. The amount of pressure-change observed in this portion of the lumbar spine varies directly with the force and extent of this rotation.

I have already, in a previous paper in the ' Trans. Path. Soc.' (" Pressure-Changes in the Lower Part of the Spinal Column "), referred to work done by Professor Neugebauer, of Warsaw, in connection with the divided condition of the vertebral arch of the fifth lumbar vertebra, and in it I criticised the views which he put forward as to its causation, as well as that of spondylolisthesis. He has, I find, described two cases,* or rather specimens (for he only describes a portion of the body, and makes no mention of any change observed in the rest of the skeleton), in which the fourth lumbar vertebra was divided into two parts, in a manner which, as far as one can judge from his diagrams and descriptions, appears to resemble the condition I have described in this paper. As in the case of the

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* " Aetiologie der sogenannten Spondylolisthesis," 'Archiv f. Gynækologie,' Bd. xx, Heft 1 ; and " Ein zweiter Fall von sogenannten Spondylolisthesis am vorletzten Lendenwirbel," 'Archiv f. Gynækologie,' Bd. xxi, Heft 2.

fifth lumbar vertebra, so also in that of the fourth, he
considers that the division of the vertebral arch must be
the result of one of two causes, either that the arch had
been fractured in two points and the fragments have not
united, or that several bony centres had never united to
render the arch complete.   I will quote his own words,
" Die Urasche der letzeren " (namely, the divided condition
of the arch) " ist in beiden Fällen zweifelhaft (Fractür oder
congenital begründete Lysis?—letzere angesichts der
grossen Analogie der zahlreich beobachteten Fälle bedeu-
tend wahrscheinlicher)."   For the reasons which he gives
for ascribing this condition to non-union of the bony centres
I must refer the reader to his writings on the subject.   I
will not express any opinion on the two cases he has
described beyond saying that the conditions of the fourth
lumbar vertebra, which he illustrates, seem almost identical
with those I have described, and, as I stated, concerning
the cases of divided fifth lumbar vertebra which I dissected,
so I would assert of this example of divided fourth lumbar
vertebra, *that the causation of the condition is pressure and
not fracture or a non-union of bony centres.*

In Professor Neugebauer's cases, as in mine, there was
a certain amount of forward displacement of the fourth
lumbar vertebra, but I think that I have already sufficiently
accounted for it, and an examination of Figs. 84 and 85
renders the mode of its occurrence at once obvious.

Although I altogether disagree with Neugebauer in his
views upon the causation of the conditions alluded to, I
must congratulate him on the many very interesting obser-
vations he has made, and the care with which he has
worked out the details connected with them.*

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* Professor Sir W. Turner has described several cases of want of union of
the neural arch with the body of the fifth lumbar vertebra, which he ascribes to
imperfect development. See his ' Report on Human Skeletons, Challenger Reports,'
vol. xvi, 1886.

CHAPTER VI.

THE ANATOMY AND PHYSIOLOGY OF THE SHOEMAKER.*

THE body—the changes in whose anatomy forms the subject of this paper—was sent to the hospital for dissection. I was therefore enabled to observe accurately every structural variation that had resulted from the habitual performance of a definite series of movements, entailing the expenditure of a considerable amount of muscular energy during the greater part of a long lifetime of seventy-three years.

Having concluded, from a careful examination of the changes which the body presented, that the man had been a shoemaker, I wrote to the medical officer of the infirmary in which he died for any information he could give me, and he kindly informed me that the man was entered on the books as a shoemaker.

An occupation such as this is one which, when the person engaged in it is in very indigent circumstances, is carried on without variation during the whole adult lifetime of the individual, and is not, as in many kinds of labour, relinquished of necessity as old age approaches for others which are less laborious. I believe that it is by the careful observation of the changes in form and structure which bones, joints, and muscles undergo, when exposed to the influence of a series of definite movements, that we

* 'Journal of Anatomy and Physiology,' 1887–1888.

shall obtain an accurate insight into the various factors that determine not only the variations in the character of these structures in individuals of the same race, but also in members of the different races of man and of the quadrumana, together with the manner in which the factors evolved by an alteration in habits, resulting from a change in the surroundings, experience, etc., of the individual, cause alterations in the shapes of the bones, etc., and so produce new types.

I would therefore make no apology for describing most minutely the deviations from the normal type which the skeleton of this man presented, were it not that I feel such a description would prove very tedious to my readers. On that account I have rendered the descriptions of the anatomical conditions *as brief as possible*, though I trust not too brief to be intelligible. In considering these changes, I will proceed in a manner the reverse of that which I was obliged to pursue in examining the body, since I was at that time uncertain as to the man's occupation. The reader is probably familiar with the manner in which shoemakers perform their work, so that I need hardly describe its details. I will select the most important function, namely, the process of hand-sewing. Other portions of their work are laborious, but they are not of a character to produce much structural alteration. In sewing the boot the last is fixed firmly between the front of the chest and the upper aspect of the thigh, and the awl is used for making holes, through which the waxed threads are passed and then pulled tight. This pressure produced a marked alteration in the form of the thorax, which was so extreme that one would suppose that it must have been noticed through his clothes during lifetime.

On removing the skin and soft parts from the front of the chest, the lower portion of the sternum was found to form the floor of a deep concavity, below which there was

on each side a large prominence, produced by the eversion and projection forwards of the sixth, seventh, eighth, and ninth costal cartilages.

The anterior surface of the gladiolus, and especially of its lower half, was covered by *a thick layer of dense fibrous tissue*. This was evidently produced by the blending of the *enormously hypertrophied anterior chondro-sternal ligaments* with those immediately adjacent on the same side, and with their fellows across the middle line. On cutting through this fibrous layer a subjacent layer of soft vascular tissue was exposed.

Crossing transversely the front of the manubrio-gladiolar articulation was a similar, though separate, hypertrophy of the second anterior chondro-sternal ligaments.

On removing this there was exposed in the middle-line a *vertical anterior manubrio-gladiolar ligament* of considerable strength, and possessing apparently but little elasticity. It was half an inch in breadth, and its margins were thick and well defined. It was attached above to the front of the manubrium, immediately above its lower limit, and below to a corresponding portion of the gladiolus. It crossed the centre of the manubrio-gladiolar articulation, and its fibres were rendered very tense when pressure was exerted upon the anterior surface of the gladiolus.

The *manubrio-gladiolar articulation* was very broad. It permitted of no rotation of the manubrium around its antero-posterior axis upon the gladiolus, the articulation having been apparently converted into a *hinge-joint*, the manubrium and gladiolus moving upon one another only around a transverse axis, which passed through the joint connecting them.

The concavity formed by the anterior surface of the lower portion of the gladiolus occupied a vertical plane $2\frac{3}{4}$ in. behind that in which the extremities of the

projections formed by the seventh, eighth and ninth costal cartilages lay.

The xiphoid cartilage was completely ossified, and was connected by bone to the gladiolus. It was curved in such a manner that it prolonged the plane of the concavity of the anterior surface of the gladiolus, and its lower extremity was tilted forwards. It was narrow, but thick and strong, and on transverse section it was found to be triangular, the base of the triangle being directed forwards.

While the trunk rested in a supine position upon the table, the posterior sharp angle of the ossified xiphoid cartilage was separated from the front of the spinal column by an interval of $1\frac{1}{2}$ in., but when the body was placed in the sedentary attitude, the sharp posterior margin of this portion of the sternum was separated by a small interval of but $\frac{3}{4}$ in. from the spine. This small interval was occupied by the liver, diaphragm, and aorta, all of which appeared to be considerably compressed.

The second to the seventh costal cartilages presented very abundant osseous change, which increased in amount from above downwards, and was more extensive on the left side than on the right.

In the normal human subject the manubrio-gladiolar articulation performs two distinct functions, one of which is to permit of the rotation of the manubrium and first and second costal arches around an antero-posterior axis upon the gladiolus; the other is to allow of the gladiolus moving upon the manubrium around a transverse axis passing through the manubrio-gladiolar articulation. The manner in which this articulation is developed, the necessity for its existence, and the factors determining its evolution, I have discussed fully in previous papers.*

Now, in the shoemaker, the gladiolus sustained upon

* "The Causation of some of the so-called Congenital Abnormalities and Variations," 'Journal of Anatomy and Physiology,' 1887, etc.

its anterior surface habitually an enormous amount of pressure. This resulted partly in the local change which this bone and the cartilages connected with it had undergone. It also produced an extreme flexion of the manubrio-gladiolar articulation, and rotated the manubrium very forcibly around a transverse axis passing through it. Owing to its very intimate attachment to the manubrium, the first costal arch sustained a very great strain, which tended to twist the first cartilages around an axis passing through their length and to displace the heads and tuberosities of the first ribs upwards from their articulations with the body and transverse processes of the first dorsal vertebræ.

In consequence of the habitual presence of these powerful tendencies to the production of excessive movement, and with the evident object of opposing and limiting them, the following very remarkable conditions resulted :

The manubrio-gladiolar joint assumed the character of a hinge-joint, and permitted of movement of the gladiolus upon the manubrium only around a transverse axis, and in order to limit excessive flexion of these bones upon one another a very powerful anterior manubrio-gladiolar ligament was developed.

The strain sustained by the first costal cartilages resulted in their very complete ossification, and though it was necessary that some joint should develop in the rigid cartilage, yet this joint was placed very obliquely, its outline was remarkably irregular, and the movements permitted in it were very limited. By the prolongation of its opposing articular surfaces downwards and inwards in an irregular manner the movement of the manubrium around a transverse axis was still further limited and resisted as much as possible. The habitual tendency to the upward displacement of the head and tubercles of the first ribs resulted in the considerable increase in the thick-

ness of these ribs, in the strengthening of the costo-
transverse articulations, and in the formation of cup-shaped
cavities for the heads of the first ribs, similar in character
to those I found in the coal-trimmer,* in which the tendency
to upward displacement of the heads of the first ribs,
which determine the development of the cup-shaped
articular cavities, resulted almost entirely from the functions
performed by the shoulder-girdles.

The pressure sustained by the front of the chest,
besides producing a change in the form of the sternum,
produced a remarkable limitation of movement in the
costo-vertebral articulations. This was most marked in
the case of the sixth ribs, which were ankylosed to the
bodies and transverse processes of the vertebræ, with
which they originally articulated. It was also sufficient to
limit very considerably, if not to prevent completely, any
movement of the upper half or more of the chest during
respiration. It would appear that, under these circum-
stances, the diaphragm performed nearly the whole of the
function of filling the lungs with air ; in fact, respiration
was then purely diaphragmatic.

The proportion which is normally borne by the muscu-
lar and tendinous constituents of the diaphragm to one
another was materially altered in this subject. The
muscular portion was remarkably thick, and encroached
very considerably upon the area which is normally ten-
dinous. Thick bundles of muscle-fibre projected promi-
nently from the under surface of the muscular layer.

The pressure sustained by the soft structures which
intervened between the xiphoid cartilage and spinal column
resulted in much change in their form and relative positions
one to another, and to the thoracic parietes.

* " A Remarkable Instance of the manner in which Pressure-Changes may
enable us to determine the Labour-History of the Individual," ' Journal of Anatomy
and Physiology,' 1887. See Chapter V.

The liver was displaced downwards by the apposition of the anterior and posterior walls of the chest, the pressure exerted by the xiphoid cartilage having severed almost completely the right from the left lobe of the liver. The left lobe, so separated, bore an abnormally small relation to the right.

The separation of the upper concavity into two separate domes caused the right lobe of the liver to be crushed up laterally into the right dome, this compression resulting in the formation of the three antero-posterior grooves upon its upper surface. *The obvious mode of production of the fissures in this liver proves that fissures in the liver can be produced by pressure acting upon it either directly or indirectly.* It seemed that the nipping of the liver and other soft structures between the xiphoid cartilage and spinal column rendered the arch of the diaphragm very tense in the middle line, and by pulling upwards upon the conjoined crura it diminished the calibre of the orifice for the aorta, and so constricted this vessel at this point, and produced the dilatation of the thoracic aorta.

Or it is possible that the pressure which the third piece of the sternum exerted upon the diaphragm, where it covered the lower portion of the thoracic aorta, might have rendered the aortic orifice more oblique and its antero-posterior diameter correspondingly less. That the resistance which was offered at this point to the passage of blood was considerable was shown by the considerable and abrupt diminution in the calibre of the vessel, though no branch had arisen between the points at which it was measured, and by the abrupt line presented by the athero-matous change in the walls of the artery.

On removing the diaphragm and front of the chest, and exposing the aorta, that vessel was seen to be abruptly dilated above the aortic orifice in the diaphragm. Although no large branch came off between the points measured, the

diameter of the lower extremity of the thoracic aorta was $1\frac{3}{16}$ in., and that of the upper extremity of the abdominal aorta $\frac{15}{16}$ in., the diameter of the thoracic aorta showing an excess of $\frac{1}{4}$ in. The position of the margin of the aortic orifice in the diaphragm was indicated upon the aorta by an abrupt transition from an opaque white colour, which was presented by the lower $2\frac{1}{2}$ in. of the thoracic aorta, to the colour presented by the abdominal aorta, which appeared to be quite normal. The opacity of the coat of the thoracic aorta blended less abruptly above with the upper portion of the thoracic aorta, whose colour resembled that of the abdominal aorta and other large vessels.

The cœliac axis came off from the left portion of the anterior aspect of the thoracic aorta nearly $\frac{3}{4}$ in. above the aortic ring, and it passed with the aorta through the same aperture in the diaphragm. A calcareous atheromatous plate in the wall of the aorta surrounded the orifice of the cœliac axis, and that vessel itself appeared to be dilated, while its walls were opaque and atheromatous. The branches of the cœliac axis below the diaphragm were apparently quite normal.

On placing the body in the sedentary posture it was observed that the convex sharp margin of the xiphoid cartilage pressed upon the opaque portion of the thoracic aorta.

On opening this vessel the inner coats of its lower portion presented a considerable amount of atheromatous change, which was most marked in and about the origin of the cœliac axis. Similar, though less marked, degenerative changes were present in the abdominal aorta.

The upper portion of the thoracic aorta showed very slight atheromatous deposit.

The heart was not large. There was a considerable amount of fat surrounding it; but it was impossible to

determine whether the muscular fibre had undergone any
fatty degeneration or not.

At first sight the changes which were presented by the
trunk and the head and neck appeared very complex
indeed.

If one were not already very familiar with the existence
of remarkable changes in form which bones will undergo
when they are subjected habitually for a long period of
time to the influence of a tendency to produce certain
changes in form, one would have felt inclined to relegate
some of the conditions which this spinal column presented
to that ill-defined class comprised under the terms *congenital
abnormality* or *deformity*. I refer to such changes as the
prolongation upwards of the transverse process of the atlas
and its articulation with the jugular process of the occipital
bone. I have seen the beginning of this condition on two
previous occasions. However, with the exercise of a little
perseverance in the study of the changes of a transitory
nature which this portion of the body undergoes in different
attitudes, the causation of these phenomena, which were
at first very obscure, became clear and well defined. The
reader will best see the manner in which the fixed and
exaggerated conditions presented by this body were
produced by assuming the sedentary posture of the shoe-
maker while engaged at his work. Let him then fix firmly
a last between the chest and the upper aspect of the right
thigh, and while he retains the article in this position let
him think out carefully what position the several portions
of his column, the head, thorax, and pelvis, are occupying.
He will then be able to ascertain that the anatomy of this
shoemaker represents simply the fixation and subsequent
exaggeration of the position and tendencies to change
which were present in his body when he assumed the
position for a short period of time.

He will find that, in order to exert a suitable and

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sufficient pressure upon the last and boot, he will rotate his thorax around a vertical axis, as well as around an antero-posterior one. He will throw the left chest forwards, at the same time depressing it, and the right chest back-wards, raising it a little also. He will feel that the lower true costal cartilages on the left side transmit a larger proportion of the pressure than those on the right.

In consequence of this position assumed by the chest, the dorsal spine forms a curve with its convexity to the right, while its normal curvature in an antero-posterior plane is slightly increased. This portion of the column is fixed, since the pressure exerted by the last upon the sternum and costal cartilages, and the muscular action brought to bear upon the thorax, in order that it may support this pressure, practically renders it so.

In order that the thorax may be brought into such a vertical level as regards the right thigh, that it may be able to fix the last upon it, it becomes apparent that the fixed dorsal spine is rotated upon the pelvis and lumbar spine by means of a vertical rotation of the last dorsal vertebra upon the first lumbar, of the first lumbar upon the second, and probably in a diminishing degree to the fourth and fifth, since the fifth lumbar does not rotate upon the sacrum around a vertical axis ; also, that the normal anterior convexity of the lumbar curve is diminished, the anterior portions of the lower, and especially the lowest, fibro-cartilages being compressed, and a tendency to the forward and downward displacement of the lumbo-sacral articulation being present. Since the sacro-iliac synchon-drosis is flexed, there exists a tendency to the induration or the partial or complete removal of the fibro-cartilage where it is compressed between the opposing surfaces of bone drawn violently together by the tightly drawn fibres of the posterior sacro-iliac ligaments, and by the ligaments and fibro-cartilage of the pubic symphysis. The lumbar

region must also present a lateral curve, whose convexity is to the left, and the upper extremity of this convexity, since it prolongs the concavity of the dorsal region, must lie to the right of the middle line of the body, as represented by that of the sacrum and pelvis.

The concavity of the lumbar curve is directed to the right. Now, as far as the transmission of pressure is considered, the concavity of the lumbar curve cannot be regarded as being limited to that region, since the right thigh is fixed by the tonic contraction of powerful muscles to the right innominate bone, and the innominate is drawn vigorously to the lumbar spine and right chest ; therefore, we must consider the concavity of this arch as being formed by the lower half of the convexity of the dorsal spine, the concavity of the lumbar spine, the upper portion of the body of the sacrum and its lateral mass on the right side, and the innominate bone. Practically, the symphysis pubis may be fairly regarded as forming a portion of the concavity of this arch.

The fibro-cartilages, which enter into the formation of this concavity, must be compressed by the considerable amount of pressure transmitted along it, so that there exists a tendency to their destruction, and to the lipping and subsequent ankylosis of the margins of the adjoining bones.

It is obvious that, as a considerable amount of movement around a vertical axis takes place between the comparatively fixed dorsal spine and the upper lumbar vertebræ, ankylosis will not take place in this region, but that the fibro-cartilages connecting the bodies, and the form and extent of the articular surfaces covering the articular processes of these vertebræ, will be altered in order to allow of free rotation. There will, however, exist a tendency to the increase of the opposing areas of the bodies of the vertebræ, especially in the direction in which

rotation takes place by means of the marginal deposit of bone.

In the case of the lowest lumbar and lumbo-sacral articulations, the tendency to the destruction of the fibro-cartilages in the concavity of the curve is still greater; and again in the lower dorsal articulations and in the right sacro-iliac synchondrosis, owing to the comparative fixity of these structures, the tendency to fusion is very much stronger.

It is apparent that both in the movement of flexion of the sacro-iliac joint, and in that attitude which may be regarded as one of abduction of the ilium upon the sacrum, there must exist a strong tendency to the separation of the two pubic bones, both in a horizontal and in a vertical plane. This tendency, if habitually exerted, would lead to an increase in the strength of those ligaments which oppose it.

In sewing the boot the head is held well forwards, directly above the work on the right thigh. On this account the anterior convexity of the cervical spine is diminished by the compression of the front portions of the fibro-cartilages. The occiput is also flexed upon the atlas, and the transverse ligament and check ligaments sustain much strain. There is also developed a well-marked lateral curve, whose convexity is directed to the left. This curve occupies the upper dorsal and nearly the whole of the cervical region, and the amount of compression sustained by the fibro-cartilages, where they form a part of the right antero-lateral aspect of this portion of the column, is greater than it is in the antero-lateral surface, which corresponds to the convexity of the curve.

Since the head is retained vertically, or nearly vertically, as the base of the skull looks downwards and slightly to the right, the occipital bone and the upper three or four cervical vertebræ form another lateral curve, whose con-

vexity is directed to the right. There must exist, then, a considerable compression of the left antero-lateral portion of the fibro-cartilage, which connects the axis and third cervical vertebra, and to a less degree of that connecting the bodies of the third and fourth.

Owing to the oblique position which the head assumes by performing a movement of rotation around an antero-posterior axis as already described, and also to a varying and slighter degree around a vertical axis, there must exist a tendency to produce changes in the form of the condyles of the occipital bone and in the superior articular surfaces of the atlas; and these changes will work chiefly in the direction of increasing the areas of the articulating surfaces, and particularly of those on the left side.

I think that it is perfectly fair to assume that during the performance of this work there must also exist a tendency to the development of some formation upon or from the upper surface of the left portion of the lateral mass of the atlas, in order to support the superjacent portion of the base of the skull, and so to counteract a tendency which is present to the excessive rotation of the head upon the atlas around an antero-posterior axis, by means of which very much strain is thrown upon the condylar joints, and the medulla placed in considerable danger.

There cannot, I believe, be any doubt that this is the explanation of the development of the new joint which was present between the strong process of bone, which projected upwards from the left portion of the atlas, and the under surface of the jugular process of the occipital bone.

This growth of bone developed in consequence of the existence of a tendency to its formation, or in other words, as the result of the existence of a demand or necessity for its presence in the same manner and for the same reasons that a similar bone-formation extended outwards from the

body of the first dorsal vertebra above the head of the first rib. As the occipital bone is habitually flexed upon the atlas, there also exists a tendency to the formation of a joint between the upper margin of the anterior arch of the atlas and the bone forming the anterior boundary of the foramen magnum.

As the shoemaker draws the threads, the head is, on account of its connection with the trunk by means of the cervical spine, thrown somewhat violently and suddenly forwards and downwards. The changes which develop in the neck during this movement may be regarded as constituting a distinct sequence. It is obvious that the first thing to take place is a violent impaction of the odontoid process in a forward and upward direction against the anterior arch of the atlas, which, with the head, is not always retained in really the same angle of rotation around a vertical axis. In consequence of the habitual performance of this movement, there must exist the following progressive tendencies, namely, to the destruction of the articular cartilage, which covers the opposing surfaces of the odontoid process and arch of the atlas ; to the eburnation of the exposed bone ; to the excavation and increase in area of the facet on the atlas, both laterally and vertically, the tendency to the increase of the vertical diameter being upwards beyond the normal upper limit of the anterior arch ; and to the corresponding and commensurate increase in the height of the odontoid process by the deposit of bone along its upper limit. The sudden increase of the flexion of the cervical and upper dorsal spine, and especially of the adjacent portions of these two sections of the column, produced by the abrupt forward and downward movement of the skull, develops a very strong tendency to the formation of an excessive amount of marginal bossing and ankylosis of the margin of the bodies of the vertebræ, since the conditions are quite

distinct from those in which pressure, however consider-
able, is transmitted steadily through bones and fibro-
cartilages. They correspond rather to those which are
present in the case of such fractures as are mended by
that form of callus which is technically described as *pro-
visional.*

A great amount of dense bone, which was present in
the anterior surface of the cervico-dorsal region of the
column of the shoemaker, was obviously dependent for its
causation upon these mechanical conditions.

The joints in the centre of the cervical region escaped
any considerable lateral destruction, for the reason that the
bodies of these vertebræ did not form a very prominent
portion of the lateral curve, and because the abrupt primary
movement of the column and the equally sudden movement
of the skull in an antero-posterior place necessitated a
certain freedom of movement in this region around a
transverse axis.

I will not weary the reader by describing all of the very
numerous changes which the spinal column and pelvis of
this workman had undergone in consequence of the exist-
ence of the tendencies I have related. It is sufficient to
state that they were such as one would expect to find on *a
priori* grounds. I must, however, describe briefly the con-
ditions presented by the upper portion of the cervical column
and by the occipital bone, since they were unusual in
character.

The left half of the body of the axis, as is shown in
Fig. 90, was in great part united by bone to the corre-
sponding portion of the body of the third cervical vertebra.
The articular processes, laminæ, and spinous processes of
these vertebræ were on the left side connected by bone.
This fusion of the laminæ had obviously not resulted from
the forcible opposition of these portions of the vertebræ,
but represented apparently an ossification of the ligaments

connecting them.   There was some similar growth on the
right side, but it was much less abundant than on the left.
The position of the original joint between the articular
processes of these vertebræ was indicated by the presence
of a prominent oblique elevation.   There was some bossing
of the margins of the articular processes of the vertebræ
immediately below on the same side, namely the third and
fourth.

The odontoid process was peculiarly modified in form.
Its height was increased by the projection upwards from
the anterior portion of its upper extremity of a thin curved
plate of dense bone.   Both this additional process of bone
and the adjacent portion of the odontoid process presented

Fig. 88 represents the anterior aspect of the atlas, with the prolongation
upwards from its anterior arch, and the large quadrilateral mass of bone
upon the upper surface of the left lateral mass.

upon their anterior surface a continuous densely eburnated
polished facet, which was convex from side to side.   It was
subdivided into two portions which occupied different
vertical places, that on the normal odontoid process lying
in front of the one above it.

There was a large vertically oval facet on the back of
the odontoid process.   This was covered by articular
cartilage, and articulated with an abnormally well-developed
transverse ligament.   Its surface was convex from side to
side, and encroached slightly upon the lateral aspects of
the process.

The remainder of the bone was rough for the attach-
ment of check ligaments, which were also very well
developed.

An accessory transverse ligament, which was attached
to tubercles immediately internal to the anterior portions

of the condyles of the occipital bone, lay in front of the check ligament and behind the upward prolongation of the odontoid process. It was apparent that it performed a function similar and accessory to that of the normal transverse ligament. This structure I have indicated in Fig. 89. The atlas presented three distinct variations, one of which at least was very remarkable. The condylar facets on its upper surface were unequal in extent, the left being longer from before backwards; a prominent little knob of bone
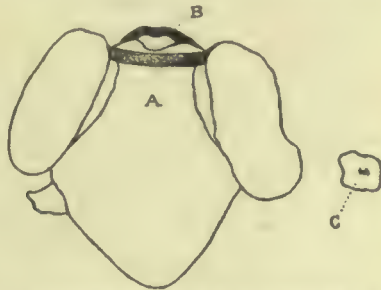
Fig. 89 represents the foramen magnum and condyles of the occipital bone. B, the groove which received the sharp free upper margin of the articular facet upon the atlas; A, the transverse ligament which lay behind the upward prolongation of the odontoid process; C, the facet on the jugular process of the occipital bone, which articulated with the mass of bone projecting upwards from the lateral mass of the atlas.

projected upwards, backwards, and outwards from the posterior limit of this facet.

The anterior arch was deeply excavated posteriorly. Its depth was nearly doubled by the deposit of bone upon its upper and lower margins, the amount of new growth above being very abundant, while that below was scanty. The large cup-shaped facet occupied the whole increased depth of the arch. Its surface was highly polished and densely eburnated. It was subdivided into two parts by a slight ridge which ran transversely across its surface. On articulating this bone with the axis, the facet described on the anterior surface of the odontoid process, and upon its upward prolongation articulated with the two parts of the

atloid facet. Its upper margin was very irregular, and overhung the floor of the cavity. On articulating the atlas with the occipital bone, the irregular upper margin of the atloid facet fitted into and occupied an irregular narrow groove with prominent edges upon the under surface of the anterior margin of the foramen magnum. This I have tried to illustrate in Fig. 89. From the upper surface of the transverse process of the atlas immediately outside and behind the vertical foramen, there projected vertically upwards a strong process of bone which was flattened from side to side. Its extremity was broad, and presented a quadrilateral rough facet upon its upper surface. This articulated with a corresponding depression on the under surface of the jugular process of the occipital bone immediately internal to the groove which attaches the posterior belly of the digastric muscle. A small synovial cavity surrounded this acquired articulation, but there was no appearance of a capsular ligament. This process of bone and the increased depth of the anterior arch are shown pretty clearly in Fig. 88.

As the head is thrown forwards with considerable violence, and especially at the termination of this forward movement, the odontoid process exerts a very great strain upon the transverse and check ligaments. The presence of this strain tends to produce the better development of these structures which oppose the backward displacement of the process of the axis.

We find here in this shoemaker, whose anatomy I have described, another remarkable instance of the manner in which the organism will provide, almost as if by instinct, if I might so use the term, a structure which is definite in its form and in its capacity for performing a certain function in response to a tendency or a necessity for its existence. I refer more particularly here to the additional transverse ligament which lay behind the upward prolongation of the

odontoid process, and was attached on either side to the margin of the foramen magnum, and which opposed its backward displacement. It is quite obvious that this transverse ligament could not have existed before the odontoid process was prolonged to its level, and that it appeared and performed its function only when the necessity for its existence arose. Its development is but one instance of a law which is abundantly illustrated by the anatomy of this subject. It is difficult to understand the exact manner, and from what such a definite structure is developed. The higher mammals are unable to reproduce portions of their body which are destroyed or injured. *They possess, however, a much more remarkable power, which, I think, is the most important factor in evolution.*

It is that they are able to produce, in response to a tendency to its development, which tendency has arisen in consequence of the individual being subjected to the influence of mechanical forces other than those that determined his evolution, a more or less complete change in the character of the anatomy and physiology of a part or of the whole of their bodies.

*If it is impossible for this tendency to result in its actuality during the lifetime of that individual, it is able to transmit that tendency to change to its offspring, in which it may produce the actuality.**

I recently applied this law to explain the changes which the skeleton undergoes in abnormal conditions, as mollities ossium, rickets, osteitis deformans, and congenital syphilis; and I was able to satisfy myself completely on its applicability to this subject.†

* "Can a Tendency which produces no Change in the Parent result in the actuality of the Change in the Offspring," 'Journal of Anatomy and Physiology,' 1887.

† 'The Factors which determine the Hypertrophy of the Skull in Mollities Ossium, Rickets, Congenital Syphilis, and Osteitis Deformans," 'Proc. Roy. Med.-Chir. Soc.,' 1887, and 'Lancet,' May, 1888.

While sewing, the thighs are flexed upon the trunk and are retained firmly in this position, in order to retain the boot and last in position, by the exercise of a considerable amount of muscular energy. By this means the upper surface of the head of the femur is retained in firm contact with the back part of the acetabulum, so that there exists a certain tendency to the displacement of the head directly backwards. In response to this tendency there is developed on the posterior margin of the acetabulum a sharp, prominent ridge of bone, and the cotyloid ligament is prolonged outwards over this.

I had never before seen such a growth of bone and fibro-cartilage upon this portion of the acetabular margin, though it is readily developed, and is frequently present in response to a similar tendency upon the upper or upper and posterior portions of the margin of the cavity in many occupations, and in morbid conditions in which the trunk is retained in a position of flexion upon the thigh.

Owing to the habitual and considerable flexion of the hip-joint, and the consequent apposition of the articular surface of the acetabulum with the non-articular portion of the neck of the femur, the articular surface of the head had been prolonged downwards and outwards over the neck by the direct conversion of the synovial membrane into articular cartilage and bone. The appearance presented by these extensions of articular cartilage upon the neck of the femur vary considerably and definitely with the cause which determines their production, and one might write a great deal about them. As in most sedentary occupations, bursal cavities of considerable size had developed in consequence of the habitual pressure sustained by the tuberosities of the ischium.

The changes which the shoulder girdles undergo in this occupation are very definite and characteristic.

After the hole has been made in the leather by means

of the awl, the waxed threads are passed through it.   Their
ends are then grasped firmly in the hands, one being
usually twisted round the awl held in the right hand, while
the other is made to encircle the palm, which is guarded
from injury by a suitable leathern shield.

By means of a sudden and violent jerk the shoemaker
pulls the threads through the hole, and by abducting and
extending his shoulder-joint he continues to separate his
hands till he has pulled through the whole of the slack.
He then gives the threads an additional jerk, expending,
as in the first movement, a great deal of muscular energy.

It would be impossible to pull the threads through the
hole made by the awl without applying to them the sudden
initial strain.   It is therefore apparent that the greatest
amount of energy is expended upon the commencement of
the movement, though throughout it all much force is
exerted.

Since the right upper extremity is used in performing
some movements in addition to those performed by the left,
we would expect to find in the right shoulder-joint less
exactly defined indications of a single succession of move-
ments than on the left side.   I refer to such movements as
hammering, polishing, etc.   It is apparent, from a little
consideration, that these movements can tend to produce
but very slight modifications in the characters of the bones
and joints, as compared to those which must result from
the habitual performance of the sewing movement for a
long period of years.   If we analyse the mode and direction
by which force is transmitted from the upper extremity to
the sternum and first costal arch in this movement in order
to determine the tendencies to change which are developed
during its performance, we see that at its commencement
the clavicle occupies a position of slight flexion and adduc-
tion upon the manubrium and first costal arch, and that at
its termination it is in a position of extreme extension and

abduction. The outer extremity of the clavicle has passed in a straight line, running from below, upwards and backwards, its inner extremity moving upon the sternum around an axis, whose direction is from above, downwards and backwards. Since this is the only movement which takes place habitually in the sterno-clavicular articulation, it becomes, for all practical purposes, a hinge-joint, and the opposing surfaces of bone tend to assume the form most useful for the performance of such movements, a tendency existing to the increase of the size of the inner extremity of the clavicle and the area of the articular cavity formed by the manubrium and first costal cartilage ; to the excessive elongation of the inner extremity of the clavicle in the direction of the axis of rotation ; to rendering the inner surface of the clavicle convex in a direction which crosses the axis of rotation at right angles, namely, from above, downwards and forwards, and to changing the form of the costo-sternal facet, that it shall accommodate the inner extremity of the clavicle in its altered form.

In drawing the threads the clavicle forms the resultant of a parallelogram of forces, one acting in a direction from without, downwards, forwards, and inwards, and corresponding to the resistance which the leather offers to the passage of the waxed threads, and the other in a direction from without, upwards, backwards and inwards, and corresponding to the strain exerted by the trapezius, levator anguli scapulæ, and rhomboid muscles, as they draw the scapula and the outer end of the clavicle upwards, backwards, and inwards.

Though the general direction of the force which is transmitted along the clavicle during the whole of the movements is inwards, yet the exact direction varies considerably at different periods of the movement.

For instance, at the commencement of the movement, when the clavicle is transmitting the greatest amount of

pressure, the direction which it takes is upwards, inwards, and backwards, so that there exists a tendency to the displacement of the inner end of the clavicle upwards and backwards ; to the destruction of the fibro-cartilage where it intervenes between the anterior portion of the inner end of the clavicle and the sternum, and of the articular cartilage covering the thin opposed surfaces of clavicle and sternum ; and to the hypertrophy of the ligaments, which oppose such a tendency to displacement of the sternal end of the clavicle. These ligaments are the posterior and upper portions of the capsular ligament and the interclavicular.

Fig. 90 represents the axis and third cervical vertebra, the prolongation upwards of the odontoid process with its articular facet, the formation of a layer of bone connecting the arches of the axis and third cervical vertebra, and the seat of the ankylosed articulation of the articular processes.

At the end of the movement the clavicle is transmitting pressure to the sternum in a direction from without, inwards, forwards, and downwards, so that there exists at this period a tendency to the destruction of the posterior and upper portion of the interarticular fibro-cartilage where it intervenes between the posterior and upper part of the facet on the clavicle and the sternum ; to the removal of the articular cartilage covering the articular surfaces of the clavicle and sternum, which come into immediate apposition after the destruction of the intervening fibro-cartilage ; also to the eburnation of the exposed bone ; to the hypertrophy of the ligaments opposing the movement and possibly to their elongation, if the movement performed

be extreme, as it is in this case, and the ligaments showing this change are the anterior sterno-clavicular and rhomboid ligaments, the costo-coracoid membrane, and the subclavius, much of the substance of which tends to retrocede under the influence of the strain it experiences; to the displacement of the inner end of the clavicle forwards and downwards, and to the elevation of the anterior margin of the chondro-sternal facet, in order to oppose this displacement.

In an intermediate position of the movement between these two extremes the pressure is transmitted almost directly inwards along the clavicle, and the tendency to produce definite and similar changes is quite obvious.
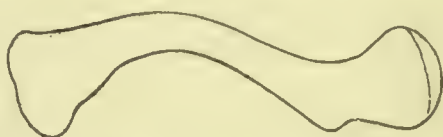

FIG. 91 represents the upper surface of the right clavicle of the shoemaker. The upper margin of the acromial facet is indicated upon its outer extremity.

The influence of the very considerable amount of force which is exerted inwards along the direction of and by means of the clavicle, added to the movement of the outer extremity of the clavicle in an oblique plane around an axis which passes at right angles to that plane through the sterno-clavicular articulation, tends to exert a very powerful influence, and finally results in the conversion of the very complex arthrodial sterno-clavicular joint into the joint of the aged shoemaker, which may be regarded as almost a perfectly ginglymoid articulation. The inner extremity of the clavicle had completely lost its normal form. It was enormously increased in size, and formed an oval extremity whose long axis ran from above downwards and slightly backwards. This diameter of the inner end

of the clavicle measured 1¾ in., while its breadth was under
an inch.

The structure of the sterno-clavicular articulation as a
normal and permanent mechanism is remarkably ill-adapted
to the performance of heavy muscular labour. When it is
subjected habitually to any great strain for a long period of
time, it undergoes very extensive changes at a comparatively
rapid rate, and the variations which are developed vary

FIG. 92 represents the anterior surface of the same bone.

within wide limits with the form of the occupation, and there-
fore with the character of the laborious movements which this
joint is called upon to perform habitually.

We will take, for instance, that portion of the joint
which, from its definite form, structure, and attachments,
shows most distinctly any alteration. I have examined a
great many sterno-clavicular joints in labourers, but have
never seen one in which the fibro-cartilage had been so
completely removed as it had been in this shoemaker, nor
in which the inner end of the clavicle and the chondro-
sternal facet had undergone such extreme and remarkable
changes in form and character ; there is, however, not the

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slightest difficulty in understanding the manner in which this complete change was brought about by the habitual movements of this workman.

The nearest approach to it which I have observed was in the body of a powerfully-built sailor. In that case the fibro-cartilage had lost its attachment to the clavicle as well as to the sternal portion of the joint. The only relic of the original structure was a densely fibrous wedge, containing minute particles of bone scattered through its substance. This was attached to the upper portion of the capsule of the joint by its base, and, projecting downwards, occupied the angular interval which existed between the two bones

FIG. 93 represents a vertical transverse section through the right sterno-clavicular articulation of an old sailor.

above. I have indicated this in Fig. 93. We are aware that the sailor performs a great many movements of different kinds with his arms, in which he exerts a considerable amount of muscular energy. Yet, though they would seem to form a very complex group, I think we can at once separate from them all those in which an immense amount of strain is thrown upon the sterno-clavicular articulation. The other movements, as climbing, etc., may demand the expenditure of much muscular exertion, but in them the sterno-clavicular articulations do not transmit the same amount of pressure. I refer particularly to two movements, one in which an immense pressure is exerted in a forward and downward direction upon the outer end of the clavicle, which occupies a position of flexion and adduction at its sternal articulation, and resting upon the

first cartilage, as in pulling upon a rope which passes through a pulley on a level with the deck.   In the other movement a corresponding amount of pressure is exerted upon the outer part of the clavicle in a backward and downward direction, that bone being extended completely upon the sternum, and resting upon the first rib.   This takes place when the man hauls on a rope which passes from behind over his shoulder.   There are many other similar movements in which force is exerted upon the clavicle, either in these directions and positions, or in inter-mediate ones, but the two extremes which I have given serve to illustrate my point.   In the first the anterior portion of the lower half of the fibro-cartilage intervenes between the surfaces of clavicle and sternum through which the force is transmitted, and it is rapidly destroyed ; while in the second movement the posterior half of the lower section of the fibro-cartilage is compressed and finally obliterated.   The dense wedge of partly ossified fibro-cartilage which remains serves a certain, obvious, definite, and useful purpose.   I might describe the varied conditions of this joint which are present in very many forms of labour, since in every one who has performed habitually any kind of heavy manual exercise some change is always present.   I think, however, that the examples of the shoemaker and sailor serve to illustrate sufficiently fully and clearly for the limits of this paper the truth of my statement.

Owing to the exact similarity of the movements of the two arms in sewing, each clavicle must impinge upon the same spot upon the costal arch.   In consequence of this, one would expect to find but a very small chondro- or costo-clavicular articulation present in the substance of the rhomboid ligament, and the opposing articulating surfaces very small and well-defined.   The large amount of pressure which the clavicles exert upon the first costal arch, together with the necessity of the fixation of the arch as regards any

rotation of it or of the manubrium around an antero-posterior axis, would assist materially in producing an early ossification of the first costal cartilages, in the development of strong amphiarthrodial joints in their substance, and in rendering the manubrio-gladiolar articulation rigid as regards movement of the manubrium upon the gladiolus around any but a transverse axis.

Nearly the whole of the force which is transmitted in an inward direction by the clavicle to the costo-sternal articulation must be applied to the outer end of the clavicle by the acromion process of the scapula.

Therefore, it is quite obvious that there must exist two tendencies to produce change in the form of this bone, which normally presents two curves in the same plane. One tendency is to produce a local change. By that I mean an alteration in the direction, form, and character of the acromial facet, and in the shape of bone immediately adjacent to it. The second tendency is to increase the curvatures of the clavicle, and so render it shorter.

Many points of extreme interest and importance arise in connection with the discussion of the results produced by these tendencies.

In the normal acromio-clavicular articulation, as it exists in the young subject, the plane of the opposing surfaces forms nearly an equal angle with the vertical and the horizontal planes; in most cases the former is a little the smaller. In many of the quadrumana which I have dissected, I have found that the plane of the opposing facets formed with the horizontal plane a similar angle.

The great advantage of such a joint in this situation is particularly obvious in these animals, since they are so habitually engaged in supporting themselves by their upper extremities. While in this attitude there exists a tendency to the separation of the opposing articular surfaces, so that if they were vertical and were separated in consequence

of the strain exerted upon the joint, a vacuum must be formed between the bones. By means, however, of the obliquity of the plane of the facets, the joint can be extended very considerably without the formation of any vacuum between the bones, or in any way limiting the freedom of movement or diminishing the security of the forcibly extended joint. The same mechanism is again made use of in the sterno-clavicular articulation in many of these small quadrumana, where it serves the same useful purpose, giving remarkable freedom of movement and strength and security to the joint. The anatomy of these joints in man and in quadrumana will, I hope, form the subject of a future communication, in which I hope to discuss very fully the factors which determine the several variations they present.

I will at present restrict myself to saying that the normal condition of the acromio-clavicular articulation is extremely ill-adapted to the performance of any laborious occupation, so that it at once undergoes a complete change when such work is engaged in.

In the normal joint I have been unable to find any fibro-cartilage present. Its development I will show to be what I might term a " suction change," due to factors other than those which determined the form of the so-called normal condition.

In association with the movement of abduction and extension of the shoulder-joint, the scapula undergoes a movement upwards, inwards, and slightly backwards, but it also apparently rotates slightly upon an antero-posterior axis. The outer end of the clavicle follows the acromion in its movement, chiefly on account of its connection to it by ligaments, the trapezius also influencing it considerably in doing so. The normal obliquity of the opposing facets must therefore be replaced at an early period of the individual's labour history by articular surfaces lying in a

vertical plane.   Since the acromial facet moves from before
backwards upon the clavicle in the form of an arc of a
circle, and since the pressure sustained by the opposing
surfaces of clavicle and acromion is greatest at the com-
mencement of the movement, the facet on the clavicle is
larger and deeper than that upon the acromion, it is slightly
convex from before backwards, its anterior portion is much
more polished and eburnated than its posterior part, and
the deposit of bone upon its upper margin and upon the
adjacent surfaces of the clavicle is much more abundant
than upon its lower.   The facet on the acromion is smaller,
and is slightly concave from before backwards.   These
local changes in the outer extremity of the clavicle are
illustrated remarkably well by the anatomy of the shoe-
maker.

In the normal acromio-clavicular joint there is a very
strong superior ligament, which is attached to the upper
surface of the posterior margin of the outer extremity of
the clavicle.   The fibres forming this ligament run forwards
and outwards to the upper surface of the acromion process.
The structure of the remainder of the so-called capsule of
this joint is very thin.   In this case there did not exist a
tendency to the displacement of the acromion in a forward
and downward direction, as in the normal subject when
the arm is hanging by the side, but there was developed
a tendency to its displacement upwards and backwards.
In consequence of the presence of this tendency, the
character of the ligaments of this joint changes, and the
direction of the fibres of the superior ligament was altered,
and a thickening was formed in the lower portion of the
capsule in what may be regarded as a well-developed
specimen of the genus shoemaker.

At the end of the movement of abduction and extension
of the humerus at the shoulder-joint, and to a less extent
throughout the whole of it, the scapula bears to the clavicle,

in its articulation with it, a position the reverse of that which it occupies in extreme flexion of the shoulder-joint. I have described the latter relationship in a paper * which I read recently before the Royal Medical Chirurgical Society, in which I showed its importance from a surgical aspect. The former relationship we may fairly describe
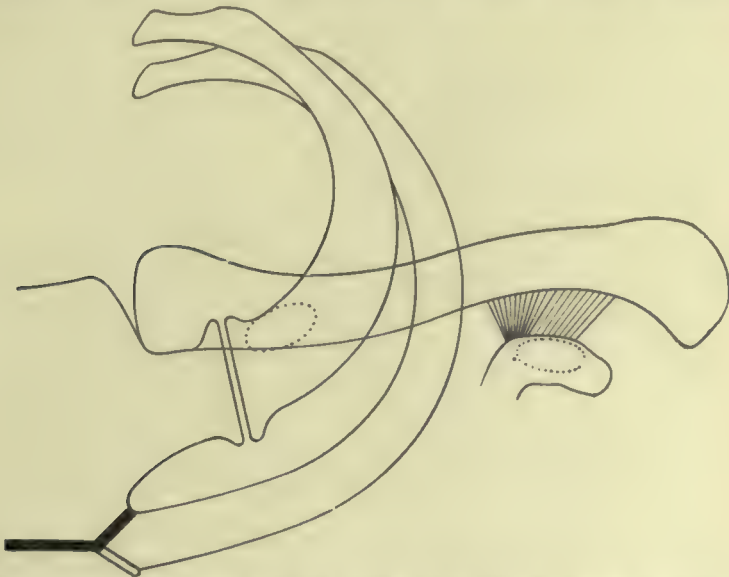

FIG. 94 represents the left first and second costal arches, with the manubrium, clavicle, and coracoid process, of a labourer. The manubrio-gladiolar joint is amphiarthrodial in character, while the joint which has developed in the ossified first costal cartilage is freely arthrodial. The position of the costo-clavicular articulation is indicated by the dotted outline on the first arch. On the upper surface of the coracoid process the facet which articulates with the clavicle forming the coraco-clavicular joint is similarly indicated.

as one of extension. In this position the upper portion of the root of the coracoid process, namely, the surface immediately in front of the conoid tubercle, comes continually into contact with the under surface of the clavicle, the conoid ligament is retained in a condition of relaxation,

* "A Mode of Fixation of the Scapula, and its bearing upon the Mechanism of Fracture of the Coracoid Process," 'Proc. Roy. Med.-Chir. Soc.,' 1887, and 'British Medical Journal,' May 19th, 1888.

and the trapezoid ligament in a state of habitual compression. In consequence of this, the conoid ligament becomes short, and forms part of the capsule of a coraco-clavicular articulation which is developed in this situation, while the atrophied trapezoid ligament remains in the cavity of this joint.

I have never, except in the case of the shoemaker, seen a coraco-clavicular articulation developed on this portion of the coracoid process. The explanation is, that in no other occupation which I have had an opportunity of

FIG. 95 represents the under surface of the clavicle with the articular facets which correspond with those on the costal arch and coracoid process.

examining has the scapula been retained habitually in such a position of extension upon the clavicle. In a large number of labours, however, the scapula is retained in a position of forcible and extreme flexion upon the clavicle, and this accounts for the frequent presence of a joint in relation with the anterior portion of the upper surface of the coracoid process (see Figs. 94 and 95).

As regards the result of the second of the two tendencies which exist, namely, to produce a shortening and increased curvature of the clavicle, I have but little doubt that the habitual exercise of a considerable force, such as that present in the shoemaker, is sufficient to produce, at least during young and early adult life, some such considerable

change in the general form of the bone as was present in this subject.

We see a similar change in the form of the long bones of the lower extremity under the influence of habitual pressure in the case of children who ride constantly bare-back ; or in the flat bones, as in the shoemaker's sternum. At the same time, I think we must allow that the extent of the change in form bears direct proportion to the loss of tone and vigour by the individual.

In the case of the shoemaker it is particularly difficult to measure the exact amount of increased curvature which is due to the exercise of this pressure, for another factor is present which complicates the problem very considerably. This is, perhaps, not quite so apparent and distinct in the case of the clavicle as I think I can make it in that of the scapula. It is an instance of what should be a well-known law, but one which does not receive the attention it deserves, nor is it applied as frequently or as generally as it ought to be. *It is that, in proportion as a muscle is exposed habitually to constant and considerable strain, in the same proportion do its muscular fibres tend to retrocede to tendon, and the bony surfaces into which it is inserted tend to grow in the direction of the traction which the muscle exerts upon them.* In the case of the clavicle, I refer particularly to the whole of the insertion of the trapezius into it, and to a portion, namely, the outer, of the clavicular attachment of the deltoid.

The same principle is illustrated in this subject by the subclavius muscles, which were so habitually exposed to considerable and sudden strain. Much of the muscular fibre of these muscles had retroceded, if one might so apply this term, to tendon, ligament, and fascia. Since, in the movement of sewing, the extremity of the coracoid process is not separated more than normally from its costal attach-ment, but is, on the contrary, approximated to it, the

thickening which is frequently present in the costo-coracoid membrane was not obvious in this subject, for the reason that there existed no necessity for its existence or tendency to its development.

Now, let us attempt to apply the law which I have just formulated to the case of the scapula of the shoemaker. In the movement of the arms in sewing the boot, the scapula is drawn upwards, inwards, and backwards in an oblique plane, the bone undergoing but a slight degree of rotation around an oblique antero-posterior axis.

Since this movement of the scapula is opposed by the very considerable resistance which the leather affords to passage of the waxed threads through it, the amount of force exerted by the muscles which produce this movement of the bone must be very great. The muscles are the trapezius and the rhomboids, and to a very slight degree the levator anguli scapulæ. We would therefore expect to find, in one who habitually performed this labour, that the surfaces into which the trapezius and rhomboid muscles were inserted were very thick and prominent, and in the case of their being marginal, that they were prolonged in the direction in which traction was exerted upon them. This was very marked in this subject. I have indicated in outline, in Figs. 96 and 97, many of the most conspicuous characters of the right scapula.

The insertion of the trapezius was very broad and conspicuous, and its large area served to assist in producing abnormally great breadth of the posterior free margin of the spinous process. The inner margin of the scapula formed two prominent convexities, which were developed in the direction of the traction exerted upon that border by the rhomboid muscles.

The humerus is moved upon the scapula from a position of adduction and partial flexion to one of extreme abduction and of considerable extension. As this move-

ment is violently opposed a great amount of force must be exerted by the muscles which produce it, and a corresponding amount of strain must be experienced by the portions of the bones into which these muscles are inserted.

The muscles which are chiefly engaged in performing the movement are the supraspinatus and the central and

Fig. 96.   Fig. 97.

Fig. 96 represents the posterior aspect of the right scapula of the shoemaker, and Fig. 97 its vertebral margin. The dotted line in Fig. 97 indicates the outline of that portion of the venter of the scapula which corresponds to the floor of the supraspinous fossa.

posterior portions of the deltoid. The anterior portion of the latter muscle takes a minor share in the production of the movement. The influence of the traction exerted by the supraspinatus upon the scapula is indicated by the very considerable eversion of those margins of the scapula into which its muscle and aponeurosis are inserted, namely, the whole of the upper and that portion of the inner which is above the level of the spinous process. I have endeavoured to represent in Fig. 97 a view of the vertebral margin of

the scapula as seen from the middle line of the body, and by means of the dotted line I have indicated the outline of the venter of the scapula, corresponding to the floor of the supraspinous fossa. Besides showing the great depth and extent of this fossa, it also gives some idea of the amount of eversion of its vertebral margin. In the same manner the traction exerted by the supraspinatus upon this margin had so influenced the position of the upper angle of the scapula, that the angle which is enclosed between a line joining the upper angle and the inner limit of the spinous process, and one joining the latter point and the lower angle of the scapula is abnormally small.

The strain exerted by the deltoid upon its scapular attachment has resulted in the enormous increase in the antero-posterior measurement of the free outer margin of the acromion, which has developed in an outward and backward direction, and it has assisted in the production of the great breadth of the posterior free margin of the spinous process.

The spinous process and acromion showed a greater increase in size than any other portion of the scapula. The breadth of the posterior margin of the spinous process measured at two points $\frac{5}{8}$ and $1\frac{1}{4}$ in. respectively, the measurements of the corresponding points in an average scapula being $\frac{1}{2}$ and $1\frac{5}{16}$ in. The outer margin of the acromion measured $3\frac{1}{8}$ in. as compared to an average measurement of $1\frac{3}{4}$ in. The plane of the clavicular facet was vertical, its area was enormously increased, and its surface was densely eburnated. The insertion of the deltoid into the humerus was indicated by the presence of a mound of rough bone which was very much larger than anything I had ever seen in this position.

A consideration of the direction in which force is exerted by that portion of the deltoid which is chiefly engaged in the performance of the movement of abduction

and extension of the humerus, and the mechanical advantages which such a prolongation of the acromion affords, renders obvious the manner in which the acromion has altered its form in response to the tendency to such a change which is habitually present.

Perhaps I can best illustrate some of the changes in

FIG. 98.   FIG. 99.

FIGS. 98 and 99 represent respectively the posterior surface and the inner margin of a scapula of a labourer who carried habitually loads on his right shoulder.

form which the scapula undergoes by describing very briefly the chief characters which it presents in another form of labour, in the performance of which a different set of movements are carried out and force is exerted along somewhat different directions.

Fig. 98 represents the posterior surface, and Fig. 99 the vertebral margin of the scapula of a labourer, who had apparently been engaged habitually in carrying loads of

considerable weight upon his right shoulder. In order to render the comparison as complete as possible, I have chosen a subject of about the same age as the shoemaker.

This has, however, the disadvantage of introducing two complications, since the labourer had not performed any very laborious work for some years before his death, and his skeleton presented senile changes which were absent in the shoemaker.

These circumstances will not interfere materially with the points to which I wish to call attention. In supporting a heavy and moderately bulky load, such as this man was in the habit of carrying upon the shoulder and upper portion of the back of the thorax, the muscles which oppose the greatest resistance to the displacement of the scapula are the trapezius and the levator anguli scapulæ, the rhomboids performing a smaller share of the work. The strain thrown upon the deltoid, the lower portion of the subscapularis and teres major muscles is considerable; while that sustained by the supraspinatus is comparatively trivial. Consequently, we find in this scapula that the supraspinous fossa is shallow, that there is not the slightest eversion of its upper or inner margins, that the vertebral margin, when regarded from the middle line of the body, presents a very perfect arc of a circle, beyond whose concavity the venter of the scapula is not seen to project; that the attachments of the deltoid and trapezius are well marked and extensive, rendering the posterior free margin of the spinous process very thick, and the outer border of the acromion longer than usual. The prolongation of the upper angle of the scapula in the direction of the traction exerted by the levator anguli scapulæ is very obvious, and the convexity of the vertebral margin in the situation of the insertion of the rhomboideus major, and the extensive surface of origin of the teres major and of the lowest intramuscular tendon of origin of the sub-

scapularis are very well defined. To discuss this scapula more fully we ought to consider the many interesting characters which were presented by the upper extremity of the humerus and by the clavicle, but these I will leave for the present as they would occupy too much space.

A consideration of these and other changes will show how useless it is to attempt to draw any definite conclusion from the formation of an average form of scapula or other bone from a number of such bones, collected together quite irrespective of the occupations or habits of the individuals from whom they were obtained. In such a study we cannot be too careful of the most minute detail, and the variations cannot be grouped under any single so-called index.

Other results of the same habitual strain exerted by those two muscles in the shoemaker are the extensive prominence of the insertion of the deltoid and the formation of a dense plate of fibro-cartilage in the tendon of the supraspinatus.

The infraspinatus and the two teres muscles exert a considerable amount of force in the production of the movement, though it is very much less than that exerted by the deltoid and supraspinatus. Therefore, we see that the markings on the scapula indicating the origin of the former muscles are proportionately less well marked than are those of the latter.

In the movement of the humerus upon the scapula the head of the former must articulate with an oblique oval area of the glenoid cavity, whose direction runs from above downwards and forwards. There must, in consequence, exist a tendency for the shape of this cavity to change and to form an oval articular facet, its long axis having the direction I have indicated ; also for the unused portion of the original articular surface to undergo changes consequent upon the absence of those movements, upon the

presence of which it is dependent for the perpetuation of its normal form in the same manner that its original form was evolved by their acquisition. Also since the force exerted by the muscles upon the arm in the production of the movement, and the resistance offered to it, are greatest at its commencement, where the lower limit of the articular surface of the head of the humerus is in contact with the anterior and lower portion of the margin of the glenoid cavity, there must exist at that period a great tendency to the displacement of the head of the humerus downwards and forwards from the articular surface of the scapula. The presence of this tendency results in the development of a process of bone from the margin of the cavity, which runs outwards and forwards, and opposes this tendency to displacement. It is covered by articular cartilage. By this means the direction of the surface of this cavity becomes altered. It no longer looks directly outwards and slightly upwards, as in the normal subject or in the quadrumana, forming nearly a right angle with the plane of the body of the scapula, but it looks outwards, backwards, and upwards, as I have indicated in the diagram. I have already shown that, under the influence of strain which is exerted vertically downwards upon the shoulder-girdle by means of the humerus for considerable periods of time, as in carrying heavy loads in the hands, the surface of the glenoid cavity undergoes a change in its normal direction. The shoulder-girdle is subjected habitually to such mechanical influences in occupations such as milkmen, a dissected specimen of which I have described in the 'Journal of Anatomy and Physiology,' pp. 388–404, 1885–1886—" Some Variations in the Human Skeleton."

It would therefore appear that a very considerable strain, exerted habitually in a downward direction by the humerus upon the shoulder-girdle for a long period of time, results in a gradual destruction of, or diminution in, the

growth of the anterior margin of the glenoid cavity, and possibly an excessive growth of its posterior margin, causing the surface of the glenoid cavity to look outwards and forwards, instead of outwards, as it does in the normal subject; also, that the momentary exercise of a sudden and considerable amount of strain, tending to displace the head of the humerus forwards and inwards from the scapular facet, results in changes in the form of that cavity the reverse of these just described, namely, an overgrowth of the anterior margin, and possibly a decrease in the extent of the growth of the posterior, causing the articular surface to look outwards and backwards. The character of the details of the changes depend largely in either case upon the age of the labourer when he commenced the particular form of occupation. This holds good for all labour and other pressure changes. This subject of the change in direction of the surface of the glenoid cavity in a horizontal plane is complicated by alterations in its direction in a vertical plane, so that in some cases the surface may look outwards, forwards, and upwards, and in others outwards, backwards, and downwards. In other cases there may be different combinations. In almost all the bodies which I have examined throughout, I have found myself able to explain the causation of the variation in the direction of the articular surface on simple mechanical principles, obtained from a study of the details of the particular work performed. I will not proceed further with the consideration of this subject in this paper, but will return to the consideration of the anatomy of the shoemaker.

The habitual performance of the movement determines a very distinct alteration in the shape of the articular surface of the upper extremity of the humerus, as in that of the glenoid cavity. The articular surface of the bone is rendered much more extensive than usual by the prolongation of the original facet in two directions. At the same

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time, two portions of the original head have become func-
tionless, since in the habitual movement they do not come
into contact with the articular surface of the glenoid cavity.
In consequence of the alteration in their function, the
cartilage and subjacent bone undergo a series of changes
which I have frequently described and illustrated. The
portions of the head which undergo these changes are the
anterior and upper portion, and the lower and back part.
The resulting articular facet corresponds in form and
direction to that presented by the glenoid cavity, its long
axis running from above downwards and forwards. The
lower portion of the original head has been prolonged
downwards and forwards, and ends in an abrupt margin,
which corresponds in position and in causation to the
growth of bone and cartilage upon the anterior margin of
the glenoid cavity. If the humerus and scapula be placed
in the position they occupy at the commencement of the
movement of drawing the thread, the surface of the scapula
is seen to be directly continuous, by means of the marginal
growth on the scapula and head of the humerus, with the
surface of the neck of the humerus, forming a complete
arch. At the end of the movement it is observed that the
upper and back part of the glenoid facet is in contact with
the prolongation upwards, backwards, and outwards of the
original articular surface of the head of the humerus.

In this shoemaker the long axis of the articular surface
of the head of the humerus measured $3\frac{1}{16}$ in., while its
greatest breadth did not exceed $2\frac{2}{16}$ in. The average
diameter of the nearly circular articular surface in the
normal vigorous adult measures about $2\frac{3}{4}$ in.

The causation of the anatomical characters presented
by the upper extremity of the shoemaker is very simple
and obvious, and its consideration will not delay us long.
The work done by the arms is very constant and consider-
able, and we therefore expect to find the bones larger than

usual, the ligaments strong and thick, and the muscles well developed and in good condition.

The reader can readily understand the manner in which the several changes have been produced by assuming the attitude of the shoemaker, and by grasping cords which are connected to a central fixed point in the hand, the cord in the left hand being made to encircle the palm, and that in the right hand being attached to an awl or similar instrument held in it. Let him suddenly exert traction of a violent nature upon the strings in the direction and manner I have already described. He will then be able to determine accurately the tendencies which exist during the performance of the single movement to deviation from the normal typical anatomy, and from a careful consideration of them he can arrive at the resulting changes which must develop in consequence of the very habitual existence of these powerful tendencies.

I will now enumerate the several tendencies to change which exist, and by referring to the anatomy of the shoemaker, the reader will be able to verify the existence of the tendencies by the presence of their actuality in that subject. In consequence of the great strain thrown upon the long tendon of the biceps as it passes over the projecting angle formed by the upper portion of the bicipital groove, a tendency exists to its acquiring an attachment to the floor or margins of that groove and to the dissociation of the portion of the long head which intervenes between that point and the glenoid cavity. The same great strain which is experienced by the tendon of insertion of this muscle while the forearm is pronated and flexed upon the humerus tends to produce an increase in the size and prominence of that portion of the tubercle into which the tendon is inserted, and in the area of the bursal cavity and articular surface of the tubercle in front of that insertion.

The same violent traction exerted by the biceps, especially at the commencement of the movement, assisted by that exerted by the supinator longus, tends to displace the head of the radius upwards and backwards from the position it occupies in this act, and to produce a proportionate increase in the thickness of the ligamentous structure which is chiefly engaged in opposing that displacement, namely, the interosseous membrane.

Since the opposing surfaces of radius and ulna are brought into comparatively forcible opposition only when the forearm occupies a position of pretty complete pronation, there exists a tendency for the portions of the articular surfaces so engaged to retain their normal articular covering, and to become more or less abruptly defined from the remainder of the articular surfaces, which, owing to their not performing the functions they are present to perform, undergo changes to adapt themselves to their altered circumstances.

The strain exerted upon the radius away from the elbow, and in the direction of the string, by the ligaments of the wrist and by the muscles which are attached to the radius, whether directly, or indirectly by means of the interosseous membrane, tends to produce a displacement of the radius in that direction, a hypertrophy of the oblique radio-ulnar ligament, the external lateral ligament, and the portion of the anterior and posterior ligaments of the elbow-joint which oppose the displacement of the radius, and the development of a vacuum in the elbow-joint.

In consequence of the presence of this last tendency we would expect to find in one who had been engaged in this occupation for many years a nearly complete synovial fringe of a firmness and size proportionate to the duration and severity of the work performed, occupying the slight interval existing between the radial head of the humerus and the head of the radius where these surfaces are

separated by the traction exerted upon the latter bone; also a very considerable hypertrophy of the intra-articular processes of synovial membrane, connective tissue and fat, which occupy the lateral notches in the articular surface of the great sigmoid cavity and the coronoid and olecranon depressions.

The habitual retention of the hand in a position of flexion, and of considerable adduction upon the pronated forearm, tends to produce an extension of the superior articular surface of the upper row of the carpus downwards upon the anterior surface of the scaphoid, semilunar, and cuneiform bones, and a consequent displacement of the attachment of the anterior radio-carpal ligaments downwards upon it; also a more abrupt definition of the posterior or ligamentous sections of the facets upon the upper surface of the scaphoid and semilunar bones. While the hand is in this position, the anterior surface of the styloid process of the ulnar is retained in forcible contact with the inner surface of the cuneiform bone, and there exists in consequence of this a tendency to the formation of facets upon the opposing surfaces of bone and of a surrounding capsule, and so to the evolution of a complete arthrodial joint. It is very curious that we should find developed in man, as the result of the habitual performance of certain movements, a condition of the wrist-joint which closely resembles that which is normal in a large number of the quadrumana, in whom the factors determining its characters are equally obvious.

There exist other tendencies to change in the wrist-joint, on account of the extreme adduction of the hand, namely, to the prolongation downwards of the inner articular surface of the cuneiform bone till it reaches the margin of the metacarpal facet, and even to the apposition of the cuneiform bone to the base of the fifth metacarpal; also, to an increase in the areas of the facets upon the

upper angle of the cuneiform bone and the under surface of the semilunar bone. The vacuum which must exist between the upper row of the carpus and the lower surface of the radius, interarticular fibro-cartilage and styloid process, in consequence of the forcible separation of these surfaces, which is due to the great resistance offered by the leather to the passage of the threads through it, must tend to the development of interarticular, synovial, or fibrous fringes of varying density from the inner surface of the ligaments surrounding this articulation, as well as to an increase in the strength and thickness of those ligaments,

Fig. 100 represents the posterior surface of the upper extremity of the left humerus. A points to a portion of the original head which had become functionless; B to the acquired articular surface; and C to an atrophic patch, all of which have been described in this paper.

and to a hypertrophy of those particular bands or layers of fibres which limit excessive adduction of the hand.

While the string is grasped in the left hand during the progress of the sudden and continuing strain exerted upon it, the thumb is retained in forcible apposition to the index finger by the powerful contraction of the flexor longus pollicis and of the several small adductor muscles of the thumb. The strain exerted upon the tendon of the long flexor of the thumb by its muscle brings the opposing articular surfaces of the bones of that digit into very forcible apposition. It tends to produce a forward displacement of the base of the first phalanx from the head of the first metacarpal bone, and, since that joint is partly

flexed, to produce very considerable change in the form of the opposing surfaces of metacarpal bone and phalanx, in the form of the lateral ligaments and in the direction of their fibres, and to determine the formation of a synovial fringe in the angular interval which exists between the two bones posteriorly.

Since the carpo-metacarpal articulation is slightly flexed, the strain exerted by the flexor longus pollicis tends to the destruction of the anterior portions of the opposing articular surfaces, to the formation of an interval between
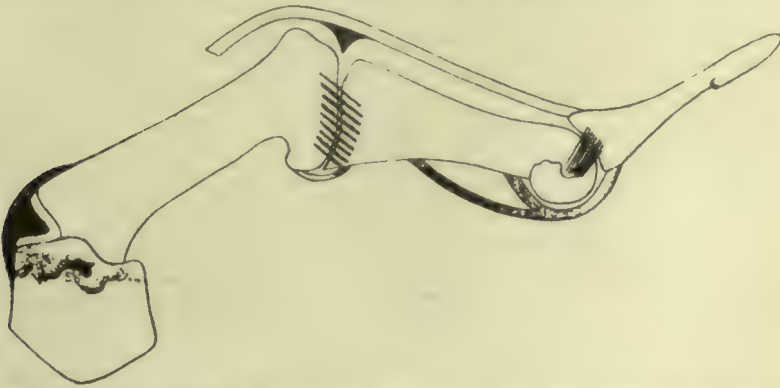

Fig. 101 represents the trapezium, metacarpal bone, and phalanges of the left thumb of the shoemaker.

their posterior portions, to the development of a synovial fringe or fibro-cartilage to occupy the interval, and to the hypertrophy of the posterior carpo-metacarpal ligament. The same violent apposition of the opposing surfaces of the base of the over-extended second phalanx and the head of the first phalanx tends to produce very definite accommodation changes in their form, as well as an alteration in the length and strength of the ligaments which oppose over-extension.

There exists a tendency to the stretching of the vaginal sheath covering the anterior surface of the first phalanx, and to the displacement forwards of the tendon of the

flexor longus pollicis from the anterior aspect of the upper portion of the bone. In this shoemaker the presence of this tendency has resulted in a very remarkable modification of the structure of the vaginal sheath. The very
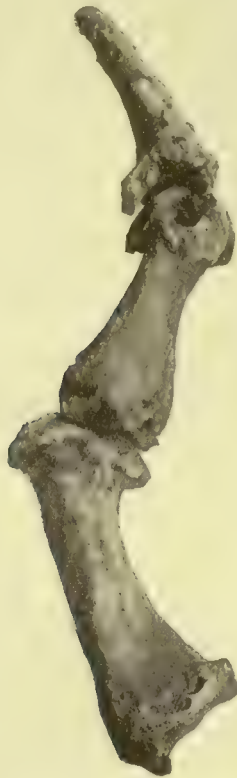

FIG. 102.—Represents the bones of the right thumb, and shows very clearly the details of the changes which have developed in this form of labour.

powerful oblique band of fibres represented in Fig. 101, apparently originating in one of the limbs of the ligamentum cruciatum, which formed the structure whose function it was to oppose and limit the tendency to displacement o the tendon, was attached below to the anterior inter-phalangeal ligament, and indirectly through it to the anterior margin of the base of the terminal phalanx.

Therefore, when the terminal phalanx was over-extended upon the proximal, the oblique band was rendered extremely tense.

The changes in the right thumb were very similar to those in the left, the differences which were present being dependent upon the fact that the awl was held in the right hand and the string alone in the left.

We seem to learn from the consideration of the anatomy of this workman, that we cannot observe and define too accurately the various modifications in form which the normal bones undergo under the influence of the groups of movements which compose some of the more routine forms of labour because they represent the fixation and the subsequent exaggeration upon the bone of the results or the tendencies produced by one single movement, in the same manner that the total labour changes in the trunk indicate in a similar manner, first the fixation, and subsequently the exaggeration of the attitude which is assumed during a single performance of the movement or series of movements habitually performed in that particular labour.

Also, because the tendency to produce change in the form of a bone may not be exerted sufficiently long or sufficiently often to produce the change in the parents, or it may, from some peculiarity in the form of the bone, be unable to result in it in either of the parents ; yet the influence of that tendency, when it acts as a hereditary factor, may be sufficient to produce or determine the presence of the change in the offspring. That this must take place to a great extent in labourers is, I think, obvious from the consideration of preceding contributions to the ‘ Journal of Anatomy and Physiology ’[*] and to the ‘ Transactions of the Obstetrical Society,’ 1887.[†]

[*] “ Can the Existence of a Tendency to change in the Form of the Skeleton of the Parent result in the Actuality of that Change in the Offspring ? ” 1888.

[†] “ What are the Chief Factors that determine the Variations which exist in the Form of the Male and Female Pelvis ? ”